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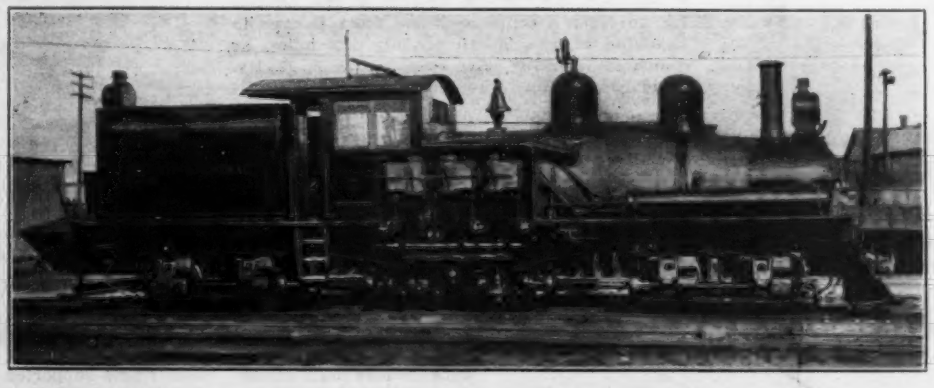
Two Interesting Mountain Railways, Operated by Geared Locomotives.

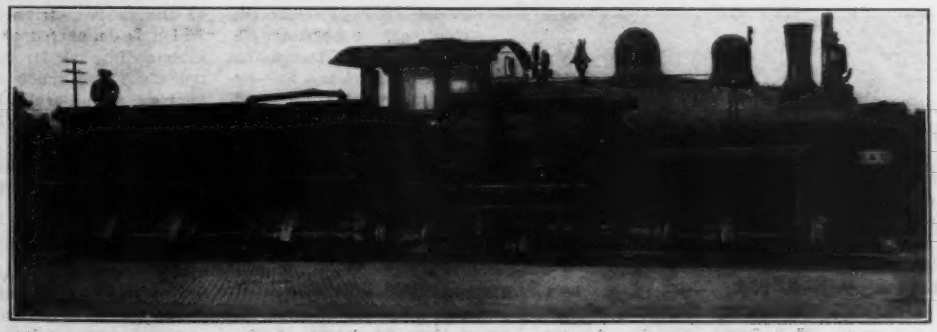
In the construction of mountain railways which are not main lines the saving of cost in construction by the use of comparatively heavy grades may be resorted to, but beyond certain limits the use of special types of locomotives becomes necessary to operate on such grades. In some cases the rack-rail system is adopted, requiring a special type of track as well as of locomotive. In other cases, adhesion engines of high power, are used (usually of the duplex articulated type); or else geared locomotives are employed, which have increased power but a consequently decreased speed. Speed, however, is not likely to be an important consideration on lines of this class. A discussion on different types of ordinary adhesion engines for steep grade railways was published in our issue of Jan. 5, 1911, and we describe below two interesting short lines which are operated by geared locomotives, two of which are shown in the photographs reproduced herewith.

The Argentine Central Ry. (Colorado).

The railways of Colorado present interesting features of construction both in regard to (1) main lines seeking routes across the mountains which will have reasonably favorable operating conditions for heavy trains and traffic, and (2) secondary lines built for the purpose of reaching certain points at high elevation.* The lines of the second class may serve mining or other settlements or may serve merely as attractions for tourist traffic; in either case the conditions of location and operation are very different from those on the main lines, and steep grades may be used freely where necessary.

An interesting line of the latter class is the Argentine Central Ry. which was built for tourist traffic but which it is now proposed to adapt to commercial purposes also by means of an extension serving a mining district. The railway, which is of 3 ft. gage, extends from Silver Plume to the summit of Mt. McClellan, a distance of 16 miles. At its lower end it connects with the end of a branch line of the Colorado & Southern Ry., which forms a route to Denver (including the noted Georgetown loop), but as this latter line is of standard gage there is no through service or interchange of equipment. A map of the line is shown in Fig. 1.





GEARED LOCOMOTIVES FOR MOUNTAIN RAILWAYS.

Above, 50-Ton Locomotive, Argentine Central Ry.; Below, 90-Ton Locomotive, Wolgan Valley Ry., Australia.

Starting from Silver Plume (9,176 ft. above sea level) the grade is about 6% for the greater part of the distance, broken at intervals by stretches of level track and 5% grades. The maximum grade is 6.6% for a short distance (combined with a curve of 286 ft. radius), and there is about half a mile of 2.4% grade. The normal minimum of curvature is 32°, but the three sharpest curves are of 143 ft. radius; a portion of one of these is on a 6% grade, the combined grade and curve resistance being equivalent to an 8% grade on tangent. The topography necessitated the introduction of several switchbacks or reversing stations, and these are approached by 6% grades in both directions. These particulars as to the physical conditions are somewhat theoretical or approximate, as the line was built by a promoter (named Wilcox) and little attention was paid to engineering problems. The promoter was a minister, who mixed business with religion by selling stock in the railway company to his congregation. He would not permit the line to be operated on Sunday (the day of greatest opportunity for pleasure traffic), and this is said to have been the cause of the failure of the original company. The present railway, as a purely tourist line, is operated only from about the middle of May to the middle of October, the upper part being covered with deep snow during the winter. It carries annually about 15,000 to 20,000 passengers.

The property was sold in 1910 to the present owners. Mr. A. J. Woodruff is President; Mr. E. J. Tuttle, General Manager, and Mr. R. H. Dwyer, Chief Engineer. The new owners could find no complete plans or profiles and no records giving exact information as to grades, curves, or construction features. Consequently a survey had to be made, but this was delayed by the snow, the line being buried until late in May, 1911.

At the summit, the end of the line is only a short distance from the top of Mt. McClellan, which is 14,007 ft. above sea level. Above this rises an arm of the same mountain known as Gray's Peak, with an elevation of 14,441 ft. The present company proposes to build an extension to this latter peak, and to build a hotel upon it,

*An article on "The Railways of Colorado" in Engineering News of April 6, 1899, described some of the topographical and construction features of these lines and included mention of the present proposed connection giving a new and short (but steep-grade) route between Denver and Leadville.

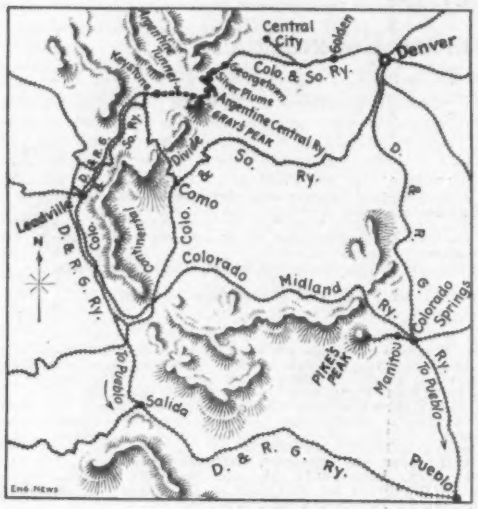


Fig. 1. Map Showing the Argentine Central Railway (Colorado) and Its Extension Across the Continental Divide to Form a Connection Between Denver and Leadville.

so that visitors may have the opportunity of seeing the spectacular effects of sunset and sunrise over the mountains. The line will then reach a point 300 ft. higher than the more widely known Pike's Peak (14,147 ft.) which is reached by a rack railway rising 7,595 ft. in its length of nine miles and having grades of 16 to 25% and curves of 16°. The distances from Denver along the Gray's Peak route, with the elevations above sea level, are as follows:

	Distance, miles.	Elevation, ft.
Denver	..	5,170
Golden	16	5,680
Idaho Springs	37	7,543
Georgetown	50	8,476
Silver Plume	54	9,176
Waldorf	63	11,666
Mt. McClellan	70	14,007
Gray's Peak	..	14,441

ARGENTINE TUNNEL EXTENSION. — As noted above, it is proposed to develop this tourist line into a freight and mining line which is to be accomplished by connecting it with the old (unfinished) Vidler Tunnel, under the Argentine Pass, and completing this tunnel so as to give rail communication with the Montezuma mining district on the opposite side of the mountain. This work is in the hands of the Montezuma & Western Ry. Co., which is closely associated with the Argentine Central Ry. Co.

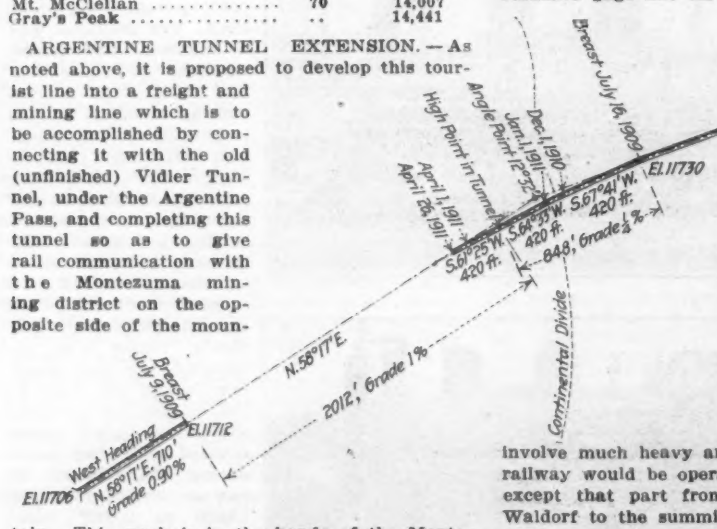


FIG. 3. PROGRESS PLAN OF THE ARGENTINE TUNNEL.

The tunnel (Engineering News, Sept. 1, 1910) was originally started as a mining proposition, and afterwards proposed as a route for a new transcontinental line (though it is at a very high elevation), and it has had many vicissitudes. The tunnel, shown approximately in Figs. 2 and 3, will be 7,536 ft. long, with grades of 0.25% to 1%, and in May, 1911, about 1,650 ft. remained to be driven. The elevation is 11,696 ft. at the east end and 11,706 ft. at the west end. In section it is only 11 × 11 ft., although parts of it are large enough for a narrow gage line. It is expected to complete this bore by 1912, and then to enlarge it to a section 14 × 16 ft., sufficient for service with narrow gage equipment. In Table I. is given a record of the progress of work at the east heading under the present ownership. The west heading is 710 ft. long, and no work has been done there for some time. After the work had extended about a mile from the east portal the haul of the muck became expensive and took up much of the time, but greater rapidity of work will be attained after the tunnel is holed through.

There is a pressing demand for railway communication to facilitate the development of the mines, for which reason the tunnel is being driven on the smaller size in order to expedite the work. As soon as this smaller bore is completed a track will be laid through the tunnel to accommodate ore traffic from mines now partly in operation and lying near the west portal. An extension of seven miles will carry the line into the Montezuma mining district, from which a large tonnage is expected. There are 144 mines idle in this district, awaiting means of shipping ore. Many are in operation also, the ore being so rich that the mines pay in spite of the excessive expense of hauling the ore by wagon and pack mules. With an additional seven miles of line, the Argentine Central Ry. can connect at Keystone with narrow gage lines of the Colorado & Southern Ry. or the Denver & Rio Grande Ry. to form a continuous line from Denver to Leadville with a length of only 122 miles, as compared with 276 miles by the D. & R. G. Ry. standard gage line through Pueblo. If the railway proves to be a success it is proposed to reduce its maximum grades from 6% to 3% and eliminate the switchbacks; this will necessitate a development increasing the length of the line by one or two miles, and the improvement will involve much heavy and interesting work. The railway would be operated throughout the year, except that part from the tunnel junction at Waldorf to the summit of the peak.

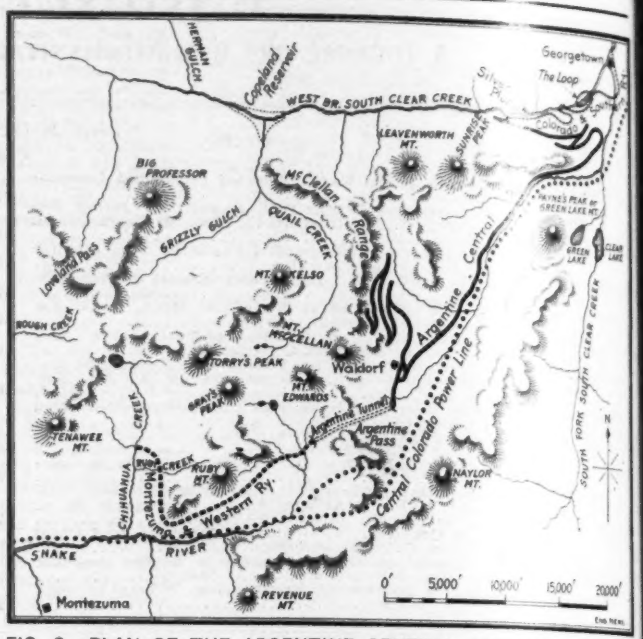


FIG. 2. PLAN OF THE ARGENTINE CENTRAL RAILWAY (SHOWING THE SWITCHBACKS).

The approximate arrangement of the strata through which the tunnel is driven is shown in Fig. 4. We are informed by the engineer that the tunnel will cut about 40 fissure veins, all highly mineralized and one assaying as high as $68 for the ton. After the completion of the tunnel the company will work some of the veins, and it is estimated that this will be a large source of wealth. It has now a mill of 75 tons capacity at the eastern end, this having been built by the old mining company. There is also the air compressor plant and electric light plant for the tunnel work.

LOCOMOTIVES. — Although the line reaches a higher elevation than the Pike's Peak Ry. it is so developed as to have maximum grades of 6½% as compared with 25% maximum on the latter line. But while no rack rail is used the line is too steep for satisfactory operation with ordinary adhesion engines, especially in view of conditions of snow and rough track, and it is operated therefore by geared locomotives of the Shay type. These are tank engines, having the boiler, cylinders and rear tank mounted on a steel frame supported on two four-wheeled driving trucks. Three vertical cylinders at one side of the firebox drive a longitudinal crank shaft which is connected at each end, by means of an intermediate shaft, to a shaft on the adjacent truck. These truck shafts carry bevel pinions gearing with bevel wheels bolted to the face of the driving wheels. Thus each axle is driven, but at one end only. The boiler is set slightly to one side of the center line in order to keep the cylinders within clearance limits. Slip and flexible joints in the shaft connections provide for the vertical and radial movements of the trucks.

In larger engines (one of which is described below) a separate four-wheeled or eight-wheeled tender is used, having its axles driven in the same way by an intermediate shaft connections from the rear driving truck of the engine; the eight-axle engines (with double-truck tender)

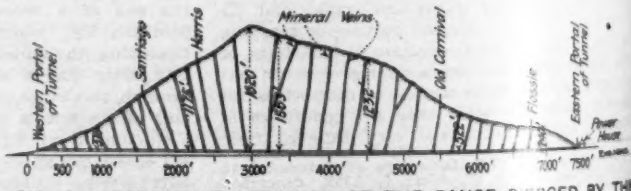


FIG. 4. APPROXIMATE SECTION OF THE RANGE PIERCED BY THE ARGENTINE TUNNEL, SHOWING THE RELATIVE POSITION OF MINERAL VEINS.

weigh nearly 150 tons with tender. These Shay geared engines are built by the Lima Locomotive & Machine Co., of Lima, O.; there are now about 2,500 in use in this country and 250 in foreign countries.

The four-axle or double driving truck locomotives of the Argentine Central Ry. (see illustration on the first page of this issue) can handle a load of about 60 tons over the line, and are capable of hauling trains of three open observation cars, each weighing about 18,200 lbs. empty. The dimensions of these locomotives are given in Table II.

The Wolgan Valley Railway (Australia).

The use of geared locomotives has been found advantageous in many cases for secondary and branch lines having steep grades and sharp curves, and on which power is more important than speed. An interesting example of their use is afforded by a steep-grade line in New South Wales (Australia), for which geared locomotives of American construction were adopted after the consideration of other types of engines. The following information is condensed from an article in "The Engineer" (London).

The Wolgan Valley Ry. was built by the Commonwealth Oil Co. to connect its coke works and oil wells at Newnes with a main line of the New South Wales Government Railways, connection with this system being made at Newnes Junction, about 86 miles from Sydney. The line is of standard gage and is about 32 miles in length. It traverses a section of the Blue Mountain district; this consists of a rough tableland ending in precipitous cliffs of sandstone which are broken by numerous ravines, while from the foot of the cliffs the ground slopes to the valley. The elevation above sea level is 3,611 ft. at the junction, 3,960 ft. at the summit and 1,760 ft. at Newnes. The summit is reached at seven miles from the junction and for the first 19 miles it was comparatively easy to secure maximum grades of 2% against the loaded traffic (south from the oil wells) and 3% against the lighter northbound traffic. For the next nine miles the line drops through one of the gorges, with numerous 4% grades and 330 ft. curves; the combined grade and curve resistance is equal to that of a grade of 4.4% on tangent. From the foot of this incline the work is easy to the terminal at the company's plant.

The greater part of the line, including its 9-mile incline is laid with second-hand double-headed 75-lb. steel rails, with nine ties to a 24-ft. rail length.

For operating this line five types of locomotives of flexible wheelbase were considered: the Mallet, Meyer, Fairlie and Garratt articulated engines (with steam trucks), and the Shay geared locomotive. The loss of steam through flexible pipe connections is said to have been an objection to all the articulated engines, while other objections were the long boiler of the Mallet engine, the double firebox of the Fairlie engine and the high cost of the Garratt engine. Eventually, the Shay geared type was adopted. Three 70-ton engines were purchased (at a cost of $11,500 each, delivered) and were followed later by a 90-ton engine. These engines were of the type described more fully above, and were built by the Lima Locomotive & Machine Co., of Lima, O.

A view of the 90-ton engine is shown on the front page of this issue. Its principal dimensions are given in Table II. The engine is similar to the one described above in relation to the Argentine Central Ry., but has a four-wheel tender with gear connections, so that all the six axles are driven. The gear ratio is 9:4 and with the three cylinders there are six impulses on the shaft during each revolution. This arrangement enables the engine to stop and start with ease on heavy grades. The ordinary speed is about 12 m. p. h.

TABLE I: PROGRESS OF ARGENTINE TUNNEL (11 x 11 FT.); ARGENTINE CENTRAL RY., COLORADO.

Date, 1910.	East Portal. Length.	East Portal. Progress.	West Portal. Length	Total completed length of tunnel, ft.
Aug. 1.....	4,038.7	...	710	4,748.7
Oct. 1.....	4,159.7	121.0	710	4,869.7
Nov. 1.....	4,291.2	131.5	710	5,001.2
Dec. 1.....	4,446.2	155.0	710	5,156.2
1911.				
Jan. 1.....	4,576.2	130.0	710	5,286.2
Feb. 1.....	4,745.2	169.0	710	5,455.2
March 1....	4,840.2	95.0	710	5,550.2
April 1....	5,023.2	183.0	710	5,733.2
April 26....	5,118.7	95.5	710	5,828.7

Total length of tunnel when completed: 7,536 ft.

TABLE II.—DIMENSIONS OF SHAY GEARED LOCOMOTIVES.

Railway.	Argentine Central.	Wolgan Valley.
Gage of track.....	3 ft.	4 ft. 8½ ins.
No. of axles, all driven	4	6
No. of driving trucks.	2	3
Pinions, No. of teeth..	19	..
Gear wheels, No. teeth	42	..
Wheelbase, rigid.....	..	3 ft. 0 ins.
Wheelbase, total.....	..	4 ft. 8 ins.
Weight, working order	50 tons	90 tons
Cylinders (3 vertical).	11 x 12 ins.	14½ x 15
Valve gear; Stephenson link with Allen-Richardson valves.		
Boiler, diam. of barrel	3 ft. 10¼ ins.	4 ft. 10½ ins.
Working pressure.....	200 lbs.	200 lbs.
Firebox	72½ x 48¾ ins.	84 x 58 ins.
Tubes (2-in.), No.....	167	246
Tubes (length).....	11 ft.	11 ft.
Heating surface, total.	..	1,526 sq. ft.
Grate area.....	..	34 sq. ft.
Coal capacity.....	..	12,000 lbs.
Water capacity.....	2,400	3,500 galls.
Brake	Air	..
Tractive power.....	..	40,400 lbs.
Ratio: Heat. surf. to grate area.....	..	45:1
Ratio: Heat. surf. to cyl. vol.....	..	355:1
Ratio: Grate area to cu. ft. of cyl. vol...	..	7.9:1

A Light Reinforced-Concrete Prison Wall at the New Jersey Reformatory, Rahway, N. J.

By WM. M. TORRANCE,* M. Am. Soc. C. E.

The first buildings of the New Jersey Reformatory at Rahway, N. J., were built about ten years ago and a wooden enclosure fence about 14 ft. high was built around the yard of the Institution at that time. This wooden fence was never strong and is always in need of repairs. Several inmates have escaped from the Institution through or over this fence and wind storms have played havoc with it on numerous occasions. The need of a substantial enclosure wall has been apparent ever since the Institution was founded, but so much money has been needed for other purposes that an appropriation for a new wall could not be obtained until last year, when $20,000 was appropriated for this purpose. The length of the wall to be built is approximately 4,000 ft., and at first it was thought impossible to obtain material sufficient to build a suitable wall of this length without an additional appropriation.

The ordinary prison wall is a massive wall which, in a height of 25 ft. (the height desired for the Rahway wall), would, with foundations on earth, contain from 4 to 8 cu. yds. of masonry per running foot. This amount of material for each lineal foot, whether of concrete, brick, or stone masonry, would, of course, cost a great deal more than $5.

When this proposed wall was first brought to the attention of the writer, the question was whether sufficient material for a satisfactory wall could be obtained for the money available.

Fig. 1 shows the design as suggested by the writer for this wall. A bill of material sufficient for 4,000 ft. of wall as shown on this drawing was drawn up and competitive bids on the material alone were received, the low bids for the various items aggregating less than $16,000. Materials were purchased from the low bidders and the construction of the wall was begun in September, 1910, about 2,000 ft. of the foundation work being done before freezing weather prevented further progress.

The labor for all this work is furnished by the inmates of the Institution, most of whom are from 18 to 24 years of age, under the directions of the regular officers, guards and carpenter and masonry instructors of the Institution.

The first 100 ft. section of the wall above the foundation was started last year, timber forms with wire ties being used. The use of timber forms was shown to be altogether too slow, for the reason that practically none of the inmates are at all skilled as carpenters. In an ordinary case of concrete construction with timber forms, as done by a general contractor under conditions that exist in this part of the country, about one-third of the total number of employees on the job would be carpenters, sufficiently skilled to receive instructions from their foreman for an entire day's work in a few minutes at the beginning of the day. In the case of this Rahway wall the carpenter instructor himself is the only skilled carpenter on the job and much of his attention is necessarily taken up in instructing the boys in his detail.

It thus became apparent that some other kind of forms must be used. Steel forms as shown in Fig. 3 were designed and competitive bids were received. The forms were ordered and were delivered about April 1, 1911, the cost being about $2,400. There are sufficient forms in this order to set up 100-ft. section of wall with enough extra lengths to make the work continuous across the joint. The expansion joints occur every 100 ft. and the 100 ft. between expansion joints is made by use of these forms in 4-ft. vertical sections, those forms on the bottom portion being removed, if desired, before the top of the wall is reached in any section and are set up for the bottom portion of another section. In this way it might perhaps be possible to construct 100 ft. of wall per week, but the number of inmates and instructors available for the work is such that the rate of progress is about one section of 100 ft. in two weeks.

Guard houses are to be placed in the southwest and northwest corners of the enclosure (the main building of the Institution being across the east end of the enclosure), and intermediate guard houses are to be placed at intervals along the

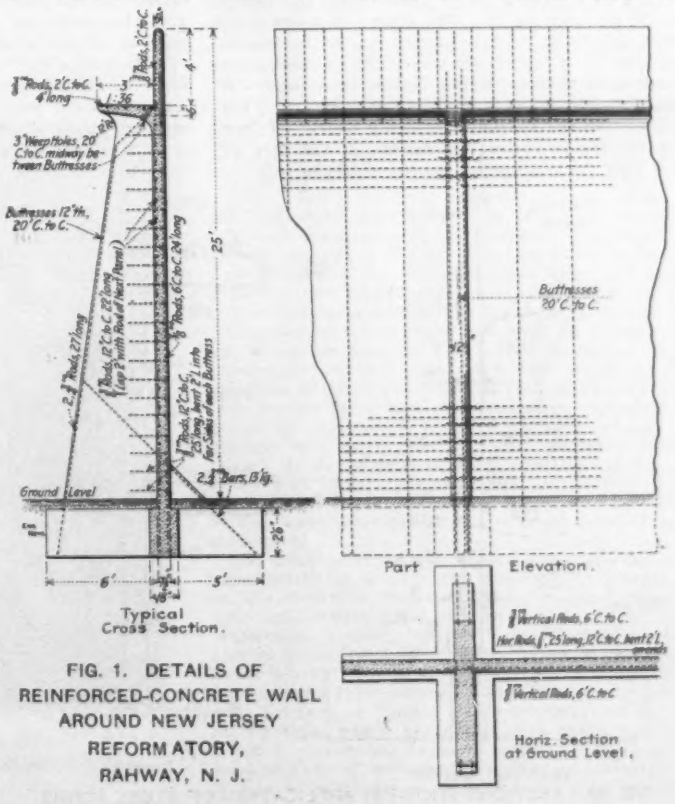


FIG. 1. DETAILS OF REINFORCED-CONCRETE WALL AROUND NEW JERSEY REFORMATORY, RAHWAY, N. J.

*Torrance & Taylor, Consulting Engineers, 39 Cortlandt St., N. Y. City.

FIG. 2. VIEW OF OUTSIDE OF PORTION OF COMPLETED WALL.

FIG. 2A. VIEW OF WALL DURING CONSTRUCTION SHOWING FORMS.

wall. These guard houses will have no communication with the interior of the enclosure, but will be accessible from the guard walk and from a steep stairway leading up from a storeroom below. This storeroom will be accessible only from the outside of the wall.

The materials being used in the construction of the wall are plain round steel bars of ⅝-in. and ¾-in. diameter, as shown on Fig. 1; a standard Portland cement; ¾-in. crushed granite; and trap rock screenings. The proportions of the materials in the concrete are one part Portland cement to 2¼ parts trap rock screenings to 4½ parts of the ¾-in. crushed granite. It is intended to bush-hammer the entire surface of the work inside and out, the bush-hammering being sufficient to remove the form marks on the concrete.

Fig. 2 shows a view of a portion of the outside of this wall as taken about July 1st. Fig. 2a is a view including some of the scaffolding and showing a nearer view of the construction from the inside of the wall.

In the design the foundations were made large enough for a maximum load of about two tons per square foot on the earth at the bottom of the wall 3 ft. below the ground surface. The loads to be considered were, besides the weight of the wall itself, a small live load on the guard walk and a wind pressure from either side taken at 30 lbs. per sq. ft. The design is made such that this wind load is carried to the buttresses (spaced 20 ft. apart) by horizontal reinforcement near each surface of the 7½-in. thick wall. A small toe buttress is made extending inside, the foundation for the buttress being nearly as long on the inside as on the outside of the face of the wall. The diagonal reinforcement in this toe buttress and the reinforcement near the outside surface of the outside buttress take the tension from the windward side, due to the overturning moment of the wind in either direction.

In designing the wall so as to obtain the desired economy a wall that is very much thinner than the usual prison wall is obtained, and the question arises whether it is substantial enough to hold prisoners who are bent on escaping; but the writer believes that even if a prisoner had tools that would enable him to break through the wall, he could not do it in a sufficiently short time or in a sufficiently quiet manner to escape detection by the guards, and this opinion is held by the commissioners and officials of the New Jersey Reformatory. Prison officials from other institutions are watching this construction with interest and many of them have expressed themselves as satisfied that this wall is satisfactory from every standpoint.

The guard walk, placed, as it is, 4 ft. below the top of the wall on the outside, renders it possible for a guard, without being seen from the inside, to pass from one portion of the wall to another, and the top of the wall gives a rifle rest in the proper position should occasion arise for a guard to use his rifle. These features of this wall are certainly improvements over the ordinary wall where the only place to walk is on the top of the wall itself and where usually there is not even a hand rail to protect a guard from falling or to give a rifle a rest in case of need.

The steel forms are so designed that when set up the horizontal joints are at the same level inside and outside. Bolt holes and bolts for splicing on the next vertical section of the forms are opposite each other on the inside and outside. This arrangement is made so that the forms may be held in parallelism 7½ ins. apart by means of the 1/16 × 1¼-in. straps shown on Fig. 3. These straps are stiff enough when in position, secured by the splicing bolts, to take any necessary compression as well as tension, and the ends which project after the steel forms are removed are cut off without difficulty, being only 1/16 in. in thickness.

On another similar job the writer would recommend thinner straps not over 1/24 in. in thickness as strong enough and the ends a little more easily cut off.

The construction work on this wall is now in progress and the plan is to continue for the balance of this season as late as weather conditions permit and to carry the work with such expedition that it will be entirely finished before the end of next season.

Prison officials, engineers or architects or any one interested in such construction work are invited to visit this work at any time. The New Jersey State Reformatory is located about one mile from the Pennsylvania Railroad station at Rahway, N. J., on the line of the electric railroad leading to Perth Amboy from Rahway. The construction work is being carried out as ordered

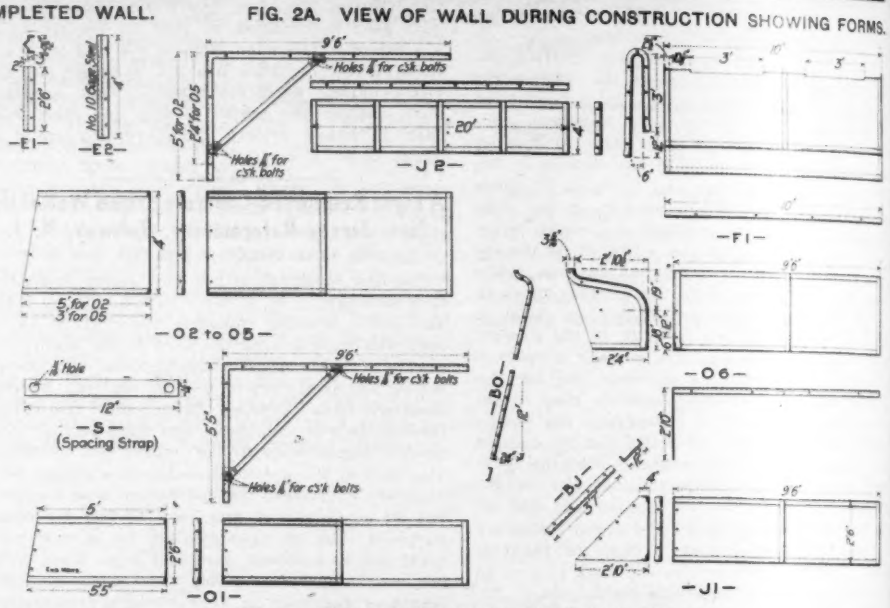


FIG. 3. DETAILS OF STEEL FORMS FOR WALL.

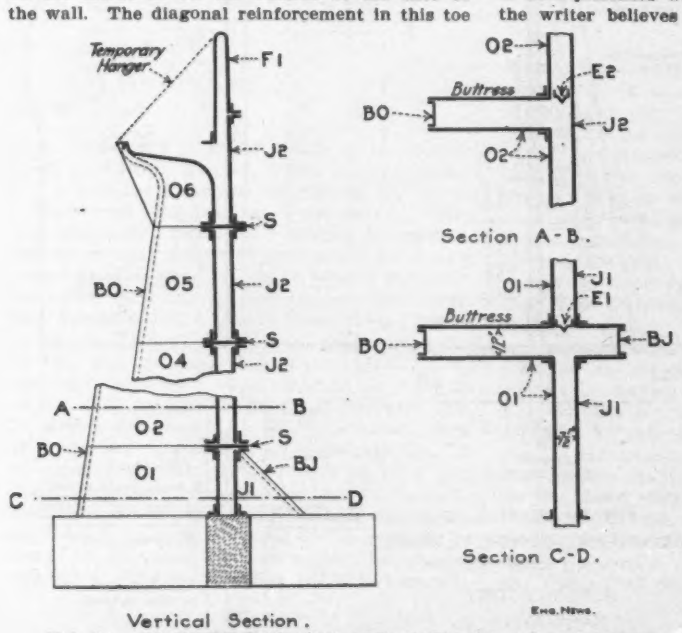


FIG. 3A. SECTIONS SHOWING APPLICATION OF STEEL FORMS.

by the New Jersey State Reformatory Commissioners (Mr. Decatur M. Sawyer, Montclair, N. J., President) and under the direct supervision of Dr. Frank Moore, Superintendent of the Reformatory.

The writer designed the wall and is retained in connection with the construction as Consulting Engineer and is in charge of the inspection.

The Electrical Precipitation of Suspended Particles From Smelter Fumes.*

By F. G. COTTRELL.†

EARLY DEVELOPMENTS.—The removal of suspended particles from gases by the aid of electric discharges is by no means a new idea. It was suggested as early as 1824 by Hohlfeld for suppressing smoke. It was brought to light again by Sir Oliver Lodge about 1884. The first recorded attempt to apply the principles commercially appears to have been made at the Dee Bank Lead Works, patents being taken out by Mr. A. O. Walker of the above firm in several countries. The apparatus installed in 1885 by the works manager, Mr. W. M. Hutchings, with the cooperation of Prof. Lodge, consisted of a system of metallic points situated in the flue from the lead furnaces and connected to two Wimshurst influence machines, having 5-ft. glass plates. The apparatus probably did not fulfill expectations, the apparent weakness being in the Wimshurst machines. In 1903 Prof. Lodge took out a patent covering the use of the mercury arc for rectifying high-potential alternating currents for this purpose.

AMERICAN EXPERIMENTS.—Some four years ago the author had occasion to repeat the early experiments of Lodge while studying the removal of acid mists in the contact sulphuric-acid process, and he became convinced of the possibility of developing them into commercial realities.

The precipitation of suspended matter in gases or liquids may be accelerated by direct or alternating current, but the mode of action and type of problem differ in important respects. With an alternating electromotive force applied, the action consists for the most part in agglomeration of suspended particles into larger aggregates, and consequently more rapid settling under the influence of gravity. Thus, if powerful Hertzian waves are sent into foggy air there is an agglomeration of the particles of liquid into drops which settle more rapidly. Considerable work has been done in France and England in the application of this to dispelling fog. While little definite result has been published, the field appears promising. Another application is found in a process for separating emulsified water from crude oil. This last process grew out of the author's work and was developed to meet peculiar conditions in the Californian fields.

In the case of large volumes of rapidly moving gases in smelter flues, the agglomerating and settling is too slow. In such cases direct-current methods have become important. If we bring a needle point connected to one side of a direct-current high-potential line opposite to a flat plate connected to the other side of the line, the air space between becomes highly charged and any insulated body brought into the space receives a charge of the same sign as the needle point. If the body is free to move, it will be attracted to the plate of opposite charge. If there are no visible suspended particles the molecules of gas themselves undergo the same process, as shown by the old familiar experiment of blowing out a candle flame by presenting a charged point to it.

The first step towards practicability was a commercially feasible source of high-tension direct current. The mercury-arc rectifier has been made practical for service up to some 5,000 volts, but higher-voltage units are suitable only for the careful management and light duty of the laboratory. The procedure actually used consisted in transforming the alternating current of an ordinary power circuit up to some 30,000 volts, and then commutating this high-potential current into an intermittent direct current by a special rotary contact-maker driven by a synchronous motor. The direct current is applied to a system of electrodes in the flue carrying gases to be treated.

The electrodes correspond to the plate and point noted. Any smooth surface answers the purpose of the plate, but the working out of practical forms for the pointed electrodes has proved the key to much of the success obtained. A single point, or a few points, worked very well in laboratory experiments, but when attempt was made to multiply such points greatly in order uniformly to treat a large mass of rapidly moving gas, great difficulty was met in obtaining powerful and effective distribution of current. By accident, it was discovered that the particular sort of distribution desired was obtained in the laboratory from a piece of cotton-covered magnet wire, which showed a beautiful uniform purple glow along its whole length. Every loose fiber of cotton insulation, though a relatively poor conductor, was still sufficiently conductive from natural moisture to act as a discharge point for the high-potential current. Its sharpness and fineness far exceeded that of the sharpest needle or thinnest wire. The greatest advantage, perhaps, lay in the less accurate spacing demanded between electrodes of opposite polarity to secure reasonably uniform discharge. In practice, a more durable material than cotton was demanded for the hot gases and this was found in asbestos and mica, the loose filaments of the one and the scales of the other supplying the points or edges of extreme fineness. These materials are twisted up with wires or fastened to suitable supports.

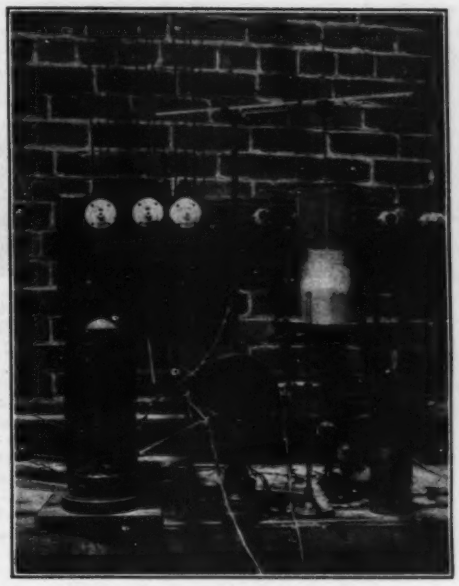


Fig. 1. Current On.

Fig. 2. Current Off.

FIGS. 1 AND 2. APPARATUS FOR ORIGINAL LABORATORY EXPERIMENTS.

Figs. 1 and 2 show the apparatus for the original laboratory experiments in 1906. Sulphuric acid mist was generated by bubbling the gas from a little contact acid plant through water in the U-tube beneath the inverted glass bell jar. An induction coil transformer took alternating current at 110 volts and gave 3,700 volts at the secondary leads, which were connected to a make-and-break operated by a synchronous motor. A momentary contact was established once each complete cycle at the peak of the voltage wave and served to charge the discharge electrode within the bell jar always with the same polarity. Leyden jars were used to help maintain the charge in the interval between contacts. In Fig. 2 the acid fume is being blown at the rate of about 20 liters per minute, the current being off. In Fig. 1 the same gas stream is flowing with the current on.

The next undertaking was to duplicate these experiments on a scale two hundred fold larger at the Hercules Works of the Du Pont Powder Co., where the contact gases from a Mannheim contact sulphuric-acid unit were placed at our disposal. These gases contained about 4% by volume of dry sulphur trioxide; to convert this into sulphuric-acid mist, the gases were brought in contact with water and the sulphuric acid, which separated as a dense white cloud of suspended particles, was so fine as to represent one of the most difficult of all materials to remove by filtration. Figs. 3 and 4 were taken

*From a paper printed in the "Journal of Industrial and Engineering Chemistry" of the American Chemical Society, August, 1911.

†International Precipitation Co., 14 Montgomery St., San Francisco, Cal.; Assistant Professor of Physical Chemistry, Univ. of California, Berkeley.

Fig. 3. Current On.

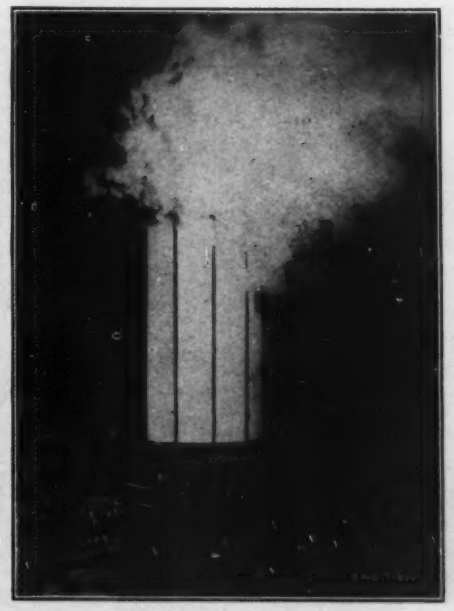


Fig. 4. Current Off.

FIGS. 3 AND 4. ELECTRICAL PRECIPITATION OF SULPHURIC ACID IN GASES FROM A MANNHEIM GENERATOR UNIT.

about a minute apart with the same current of fume-laden gases passing into the precipitation chamber, but with a current respectively on and off. For the discharge electrode, two concentric cylinders of wire screen were used, with asbestos winding. Intermediate in diameter between these two and resting on the lead pan bottom of the apparatus was a third cylinder of iron wire screen, without asbestos winding, which, together with an outer glass cylinder, constituted the collecting electrodes. The space between successive cylinders of opposite polarity was as nearly as possible 1¼ ins. Current was supplied from three 1-KW., 110/2,200-volt transformers connected to give 6,600 volts. The fume was delivered at the bottom of the precipitation chamber and had to pass through the three wire cylinders and up between the outer of these and the glass container, thus being subjected to three electric fields in succession. The power consumption was about 1/5-KW., and from 100 to 200 cu. ft. of fume per min. could be treated. This apparatus was only experimental and a larger commercial unit was built to handle all the gas from a Mannheim generator.

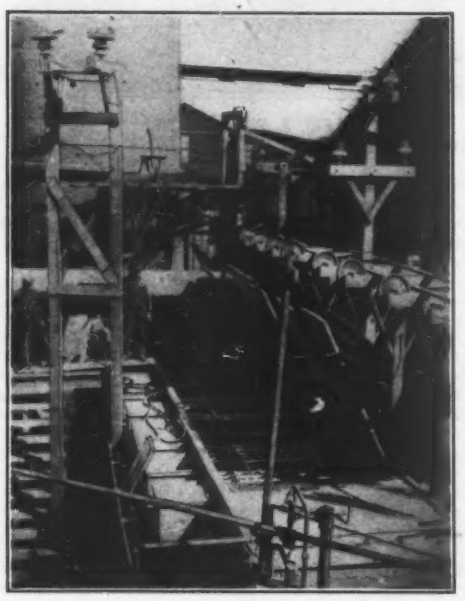


Fig. 7. Top of Electrical Precipitation Chamber; Roaster Flue of the Selby Smelting & Lead Co.

These experiments attracted the attention of the Selby Smelting & Lead Co., whose smelter at Vallejo Junction was then the object of injunction proceedings brought by the farmers of the surrounding country. The first and admittedly most serious offender, of three separate stacks, handled the gases from the lead blast furnaces and had been discharging several tons of lead fume daily into the air. This trouble had been obviated by the installation of a bag house, but there remained a stack discharging gases from the roasters, which, besides the invisible sulphur dioxide, furnished dense white clouds chiefly of sulphuric acid, arsenic and lead salts, and to which bag-house filtration was inapplicable on account of the destructive action of the gases. Lastly, there was the stack of the refinery carrying the mists from the pots of boiling sulphuric acid used to dissolve the silver out of the gold and silver alloy coming from the cupels.

Fig. 5. With Current on Precipitation Apparatus.

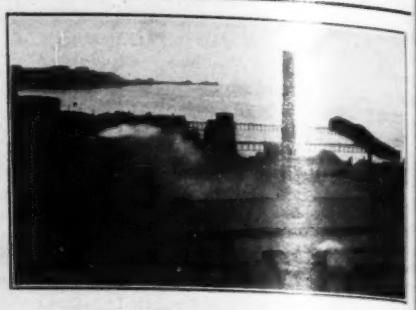


Fig. 6. With Current Off.

FIGS. 5 AND 6. REFINERY STACK OF THE SELBY SMELTING & LEAD CO., VALLEJO JUNCTION, CAL.

The blast furnace and roaster stacks carried something over 50,000 cu. ft. per min., while the refinery stack represented scarcely a tenth this volume. As a first step, we commenced operations on this latter, and after several months experimenting adopted a system of vertical lead plates 4 ins. wide × 4 ft. in length and spaced 4 ins. apart. Several rows of such plates were assembled in a 4 × 4-ft. lead flue. Between each pair of plates hung a lead-covered iron rod carrying the asbestos or mica material, the latter proving more serviceable in this highly acid atmosphere. These rods were supported on a gridwork of bus bars extending over the heads of the plates and through apertures in the flue to insulators on the outside. Figs. 5 and 6 show the effect on the appearance of the stack when the electric current is respectively on and off, the stack in the immediate left foreground being the one into which this flue discharged. The large stack in the middle background is from the roasters discussed below. A small stream of dilute sulphuric acid (about 40° B) was led from the flue; with the acid kettles at full boil, it often amounted to over 2 gals. per min. Electric current was taken from the power circuit of the plant at 460 volts, 60 cycles, transformed up to 17,000 volts and run through a synchronous contact-maker to the electrode system. A glass-plate condenser was used at first in parallel with the electric system to assist in maintaining potential between contact intervals, but this was found troublesome and unnecessary and is now omitted in this and other installations. The power consumption is about 2-KW., including the current for the synchronous motor. The switchboard, transformer and rectifier are located in the engine-room and require no more attention than a feed pump. The installation has been in successful daily operation for over three years at a cost for labor, attendance and repairs of less than $20 per month. While the plant was making enough blue-stone to utilize all the weak acid recovered, the saving on purchases paid for the entire cost of operation five times over.

Fig. 8. Current On.

Fig. 9. Current Off the Precipitation Apparatus.

FIGS 8 AND 9. ROASTER STACK OF THE SELBY SMELTING & LEAD CO., VALLEJO JUNCTION, CAL.

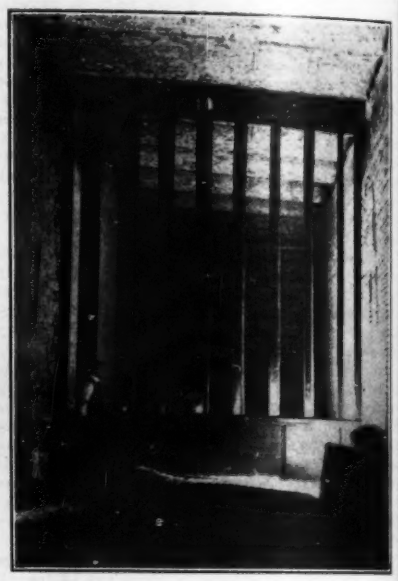


Fig. 10. Main Flue of the Balaklala Smelter.

The next undertaking was an extension of the process to the treatment of gases coming from the pyrites and matte roasters of the same plant. This was more difficult, as the material consisted of a mixture of solid dust and fume with liquid sulphuric acid. After preliminary installations on a small and a large scale the construction shown in Fig. 7 was adopted. A sheet lead flue 6 × 6 ft. and 32 ft. long contained 16 rows of 16 lead plates, each 6 ft. long by 4 ins. wide with a corresponding discharge electrode between each pair. The effect of the treatment on the gases issuing from the stack is shown in Figs. 8 and 9, which represent respectively operation with electric current off and on, being taken about three minutes apart. It should be remembered that in this 32 ft. of 6 × 6-ft. flue the same volume of gases was treated as in the blast-furnace bag house measuring 98 × 125 × 55 ft. Actual tests showed that the woolen bags used in this bag house were completely destroyed by these roaster gases in less than half an hour, so that an idea may be gained of the possibilities which this process appears to open. The power consumption in this case was between 10 and 15 KW. The material precipitated on the plates was a grayish mud easily washed off and drained out through the bottom of the flue to settlers. For this purpose it was necessary once in about four to six hours to by-pass the gases, shut off the current, raise the flue covers and clean down the electrodes from above. One man could carry out the whole operation in five to ten minutes. For continuous operation on such material it is, of course, necessary to subdivide the treatment into units so that while one is being cleaned the others may be in operation.

To ensure that essentially all the free sulphuric acid and arsenic of these roaster gases should be condensed into suspended particles, which are all the apparatus purports to collect, and also to protect the lead construction from heat, it was found necessary to cool the gases down to below 150° C. A system of water sprays was first used in the mouth of the lead flue just before the electrodes. This served very well as long as clean water was available, but as the circulating water of the entire plant is derived from the Sacramento River and is often very muddy, difficulties of keeping the sprays clean and open determined a resort to cooling by radiation through a lengthening of the flue.

The next installation in order of size undertaken was at the Balaklala smelter in Coram, Shasta Co., Cal. The smelters of this district are situated in the narrow, precipitous canyon of the Upper Sacramento and its tributary, the Pitt. The region itself is too steep and rocky for agriculture, but was once heavily wooded, although now swept bare of vegetation for miles. As far as the canyon itself is concerned, probably all the damage possible has already been done, unless reforestation were undertaken. This latter would probably be slow and difficult work, as since the loss of vegetation the steep hillsides have been washed bare of soil for miles around. At Redding, 13 miles below Coram, the canyon widens out into the fertile Sacramento Valley, and from this point southward for some 12 miles further is the region from which have come increasingly insistent complaints against the smelters. These culminated a little over a year ago in agreements between the farmers and the smelting companies, under which friendly suits were brought in the federal courts. Injunctions were issued requiring the smelters to remove the suspended matter from their exit gases and to dilute the latter to such an extent that the sulphur dioxide contained should not exceed 0.75% by volume, with the general and sweeping provision that they should do no damage. To accomplish this, the Mammouth smelter at Kennett installed a bag house which has been in very successful operation. The gases discharged are to all intents and purposes free from suspended matter and invisible. It is made possible in this instance through neutralization of sulphuric acid in the gases by the zinc oxide carried over in the fume from the very heavy zinc content of the ore smelted. It was necessary to provide an extensive system of cooling pipes, there being 39 of these, each 4 ft. in diameter and averaging 200 ft. in length. It was expected that they would be sufficient to cool the entire gases to a safe temperature to protect the $30,000 worth of woolen bags with which the bag house is filled, but it was found that a little over half the full capacity could be thus treated with safety.

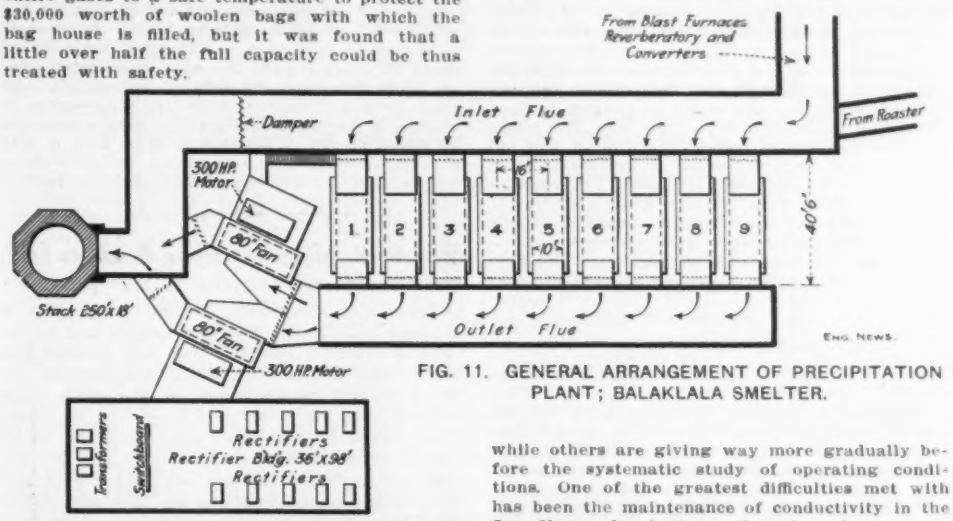


FIG. 11. GENERAL ARRANGEMENT OF PRECIPITATION PLANT; BALAKLALA SMELTER.

In the case of the Balaklala smelter, the use of a bag house was considered and a small experimental unit was run for some months in comparison with tests by the electrical process and a centrifugal apparatus in which the gases were passed through a rapidly rotating cylindrical shell with radial baffles. As a result of these tests, the electrical process was adopted for the full-size installation.

The smelter treats 700 to 1,000 tons of 2.5 to 3% ore carrying 30% sulphur with considerable but varying amounts of zinc. The greater proportion is handled in blast furnaces, but everything under an inch, amounting to less than 10% of the whole, goes through MacDougal roasters and an oil-fired reverberatory. There are two converter stands. The gases from all departments pass into a common flue of 18 × 20 ft. cross-section, an interior view of which at the main by-pass damper is shown in Fig. 10. The volume of gases varies from 250,000 to 500,000 cu. ft. per min., giving a mean linear velocity in the flue of 10 to 20 ft. per sec. A small precipitation chamber, capable of treating about 1% of the total gases, was built before attempting to design the full-sized equipment. The equipment of the whole plant was completed and put in operation in September of last year. Since then it has been in continuous operation except for the latter half of December when changes were decided upon which necessitated shutting down the plant.

Many difficulties were encountered, some of which have already been entirely overcome, while others are giving way more gradually before the systematic study of operating conditions. One of the greatest difficulties met with has been the maintenance of conductivity in the fine fibers of asbestos and scales of mica. At ordinary room temperatures these materials readily take on enough moisture to afford sufficient leakage for all the discharge necessary, and this is true at higher temperatures if the gases contain traces of sulphuric acid or other conductive matter. In the particular gases met with here, the high and variable amount of zinc oxide at times robs them of all conductive matter, reducing the conductivity of the fibers of the discharge electrodes and seriously affecting their efficiency.

Fig. 11 is a plan of the nine precipitation chambers shown in relation to the flue system and stack. The two large fans shown are not required for the precipitation system, as any added resistance due to its introduction is very slight. The fans were made necessary by that section of the court's decree requiring dilution of the sulphur dioxide. Current is received at the rectifier building at 2,300 volts, three-phase, 60 cycles, and is transformed from 25,000 to 30,000 volts and rectified into intermittent direct current, as already noted.

Fig. 12 shows a cross section through one of these units or precipitating flues as first installed. The double vertical lines represent the collecting or grounded electrodes each 6 ins. wide by 10 ft. high made of No. 10 sheet iron. The dotted lines represent the discharge electrodes consisting of two iron wire strands between which is twisted the discharge material, for which both asbestos and mica preparations have been used in this plant. Each unit contains 24 rows of 24 electrodes of each type. The collecting electrodes are carried by bars connected directly to the frame of the chambers themselves while the discharge electrodes are spanned by springs between a system of buss bars car-

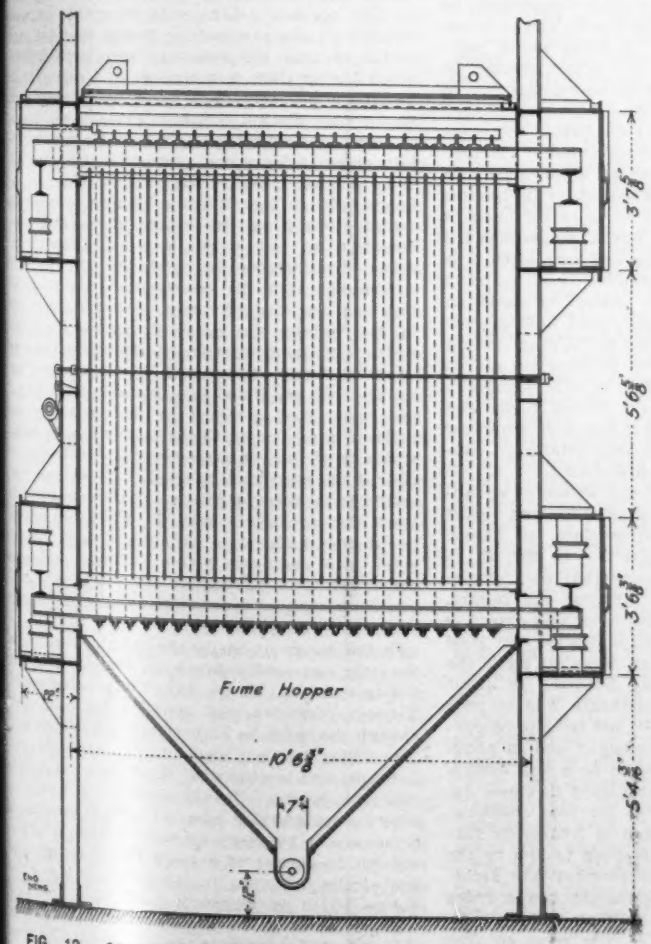


FIG. 12. SECTION THROUGH ELECTRIC PRECIPITATION UNIT; BALAKLALA SMELTER.

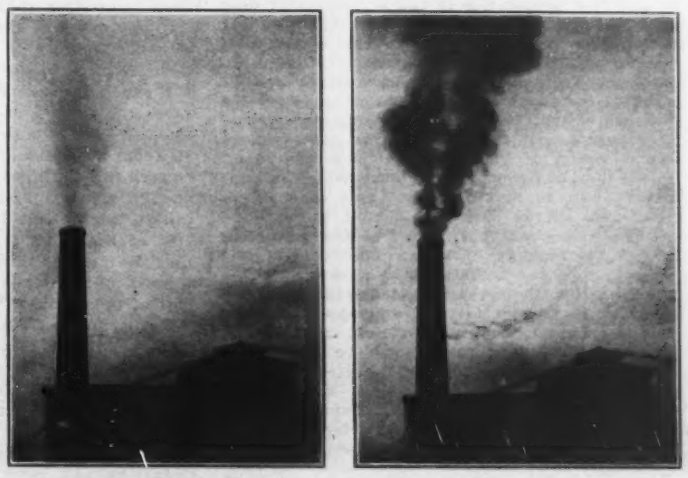


Fig. 13. Current On. Fig. 14. Current Off.

FIGS. 13 AND 14. MAIN STACK OF THE BALAKLALA SMELTER.

ried on externally placed insulators as shown in the figure. To the auxiliary chambers surrounding these insulators a small regulated amount of air is admitted to prevent conductive dust or fume from working back and settling on the insulators.

The cam and shaker rod extending across the middle of the unit was originally designed for the purpose of vigorously shaking the electrodes as it was greatly feared that the removal of precipitate from the electrodes in units of this size might be one of our most serious problems. In actual operation it has been found however that the electrodes can easily be shaken by hand from the top entirely free from dust, the whole operation including cutting the unit in and out of the system and the removal and replacement of its covers requiring only about ten minutes, and this having to be repeated every six or eight hours, depending on the dust content of the gases. The precipitated dust and fume as it falls from the electrodes is carried by the conveyor in each unit to a common longitudinal conveyor which in turn discharges into cars carrying it away for treatment and recovery of its values.

Figs. 13 and 14 are from photographs of the main stack taken a few months apart with the electric current respectively on and off. Tests were made by Messrs. Gould and Burd for the Shasta County Farmers' Protective Association, extending from March 10 to April 3, and credited the equipment with removing in that period an average of 72.8% of total solids in the gases. In nearly one-third of the individual determinations the removal of solids was over 85%. The average concentration of sulphur dioxide was 0.56% by volume, but at several times during the month the concentration rose to slightly above the 0.75% prescribed by the court. The outcome of a final hearing in the United States Circuit Court on June 19 was that the plant was required to close down completely after 35 days, until such time as it could fulfill the letter of the original decree; that is, remove all solids, never exceed 0.75% sulphur dioxide, and do no damage. Meantime, while the plant remains in operation the experimentation and development are carried on as vigorously as ever, but it is scarcely expected that a shut-down can be entirely avoided.*

This plant, including flues, fans, motors and electrical apparatus, cost less than $110,000 up to the time it was first put in operation. None of the larger or more expensive elements of construction have been greatly altered since. The total average power consumption at present is 120-KW. One man can readily control the operation, but as a precaution two have usually been on duty. Two laborers and a fireman are employed at the precipitating and dust-handling units.

The present developments in Shasta County are a suggesive illustration of what may be accomplished in the technical development of our industries by spending money on experiment and construction instead of all on litigation. Irrespective of local issues, the work done during the past year has been a real forward step in practical metallurgy. Both plants have sufficienty demonstrated their applicability to large-scale operation to ensure finding a permanent place in the field of engineering. Of the other possible applications, one of the most recent to be actively prosecuted is the collection of dust from Portland-cement kiln gases. Stimulus has been again in the nuisance to the surrounding population, which has been acute in Southern California, where several cement plants are located in the heart of a rich orange country. In the case of the Coulton plant with a capacity of 2,500 bbls. a day, an injunction has already been issued which, if sustained, will close the plant, unless they can control their dust which is estimated to be 20 tons per day. This case differs from that of the smelters in that there is no damage from gases, but merely by the deposition of a large tonnage of impalpable dust of lime and clay. On the technical side, a new condition is here met with in the high temperature of the gases to be treated (450° C and upward). The dust is entirely devoid of electrical conductivity, but notwithstanding this it can be easily and completely precipitated when the electrodes are properly adapted to the conditions. Experiments under the direction of Mr. W. A. Schmidt at the Riverside Portland Cement Works have recently been extended to treat a good portion of the gases from one kiln.

Another field in which it is hoped to find useful application is the cleaning of iron-blast-furnace gas for gas engines. There is here necessity for keeping the whole apparatus gas-tight, but no new difficulties to be overcome. This work at present is under the direct charge of Mr. L. L. Johnson, of Indianapolis.

The question has naturally presented itself of whether or not this work has any bearing on the coal-smoke problem of large cities. At present it should be said that in the great majority of cases the more logical line of attack would seem to lie in improved methods of combustion. In some special instances, however, suppression of smoke by electrical precipitation may eventually be found of use. Experiments show that it acts on ordinary smoke in essentially the same manner as upon the fumes and dust above discussed.

[*This paragraph includes a note appended to the original article in the "Journal of Industrial and Engineering Chemistry.—Ed.]

Why Do Reinforced-Concrete Buildings Fail?

By ERNEST McCULLOUGH, M. Am. Soc. C. E.*

The writer remembers a story which was a favorite with the old man who taught him geometry, in which a boy who had just reached the place where he had learned the ratio between the diameter and circumference of the circle, was walking with his father and discovered an abandoned circus ring on the village common. Anxious to astonish his father with his new knowledge he proceeded to pace the diameter of the ring, estimated the length of his pace and multiplied by π, thus obtaining the length of the circumference of the ring. The meat of the story to the old mathematics teacher, lay in the fact that the usual value of π was not close enough, so the boy must needs use $\pi = 3.1415926$. This is a very old story and appears in so many forms that no doubt it originated with the man who first proved the ratio.

The story illustrates a kink in the human mind that is sticking up prominently since the general introduction of reinforced concrete as a structural material. The mechanics of this material are not particularly difficult to understand and ordinary care will enable almost any man to use the common formulas with as much confidence as he now uses the formulas for beams and columns of homogeneous material. A great many reinforced-concrete structures are being erected of which engineers have little or no record, due to the wholesale education in the use of reinforced concrete given by the cement companies and companies manufacturing reinforcement. Nearly every contractor in the average sized town and city calls himself a concrete expert, or designates himself in such a way that he is called upon to do a great deal of concrete work. Sometimes the contractor does the designing and very often it is done by his clerks or draftsmen, if he employs draftsmen. Very often the design is based on guess work. The writer has found among such men a desire to "make it good and strong" rather than the reverse. The worst failures are not in the minor structures, but in the expensive ones where "concrete experts" (?) slaved night and day over the design, to skin it and save wherever possible, to prove to owners that reinforced concrete is cheaper than steel fireproofed.

It has fallen to the lot of the writer to be employed a number of times to examine and report upon failures in an attempt to place the blame. His experience has shown him that in 60% of the cases the design was so faulty that only exceptionally good workmanship delayed the failure. In about 30% of the cases the work was defective enough to be a large contributing cause, but good enough so that if the design were all right the failure might have been long delayed. In about 10% of the cases the workmanship was so poor that the question of design did not have to be considered, until rebuilding was begun and in about half of these cases there had to be a new design.

The writer is frequently employed to check designs. Various reasons exist for this checking. The reinforced-concrete design is frequently furnished by the contractor and given to him by the company furnishing the reinforcement. The architect occasionally has the designs checked in order to assure himself that the building will be safe. Occasionally a contractor, having received free plans and being obliged to guarantee the work under a rigid test, wants to know if everything is all right before he proceeds with his work. Sometimes it happens that a misunderstanding out occurs between the architect and contractor, or between the architect and owner, or between the contractor and owner, over the qualifications of the engineer employed to design the reinforced-concrete work. In such cases the plans are apt to be sent to the writer and thus he is enabled to study the methods of reinforced-concrete designers in many cities. Architectural engineers in the building departments of our larger cities have opportunities to study designing methods, but their plans are usually confined to designers in their home cities who are presumed to design in accordance with local building regulations. The plans coming to the writer are drawn in all the larger cities of the country and are for structures to be erected usually in places having no building regulations to act as a check on greed or incompetency.

The story of the boy who paced the diameter of the circus ring and then carefully used a factor having eight significant figures, arises often in the memory of the writer as he checks some of the plans submitted to him. Throughout the drawings the work of the designer is generally such as to attract admiration. Many sheets of drawings have been looked over with the greatest admiration by the writer, and he is free to say that in the majority of the designs the concrete details correspond to a value of $\pi = 3.141592653589793+$. In his anxiety to use this superlative refinement the average designer paces so rapidly through the work of obtaining the loads to be carried that the final design is just about as creditably accurate as was the circumference of the ring obtained by the school boy. This is why reinforced-concrete buildings are so frequently a disappointment to the owners. The reasons for the failures are not inherent in the use of concrete as a structural material. The same lack of care and exhibition of incompetency would result in failure of any structure, no matter what the material.

It was stated that a prime reason for the failure of the Quebec bridge was that the assumed weights in the preliminary design were not corrected so that the members were stressed very much higher than was proper. If a recalculation had been properly done there would have been no failure. Such a condition exists in the design of reinforced-concrete buildings today with a certain class of designers. Designers will often assume a weight per square foot of dead load for floors, add to this the live load and proceed to design, forgetting the weight of the floor construction on top of the slab and forgetting to make an allowance for partitions. This error is so common as to be monotonous. The combination concrete-tile floor is a present favorite and in determining the resisting moment the flange width is frequently forgotten, the ribs and amount of steel being determined by the weight per square foot per lineal foot, instead of the weight per lineal foot obtained by multiplying by the ratio of flange width to the foot. When the flange width is 16 ins. this amounts to a reduction of 25% of the total load, in addition to whatever else might have been forgotten. If such designers do work for architects who do not know enough about the material to be able to check the designs, can engineers blame architects for being conservative in advocating the use of reinforced concrete, after a few buildings begin to be displeasing to their clients?

In the design of beams the beam of T-section is the only one used today when there is an opportunity to use it. In the design of spandrel beams, T-beam formulas and methods are used, even though the beam be an overturned L and not a T. The writer does not know of any tests made upon L-beams and is somewhat conservative in designing such beams. Usually they are in a location where a rectangular beam will not be too clumsy, although the necessity for having the stem narrow enough to permit of a brick facing compels the use of the L-beam. In the design of beams the flange width is generally fixed by the column width or at about 24 ins. throughout, the designer evidently believing that the enclosed tile between the ribs of the floor will be good in case the flange width is greater. The writer has lately checked

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a design for a building about 100 ft. high in which the flange widths of all beams and spandrels was fixed at 24 ins. When the work was carefully gone over it was found that the flange widths varied from 21 ins. to 58 ins. What would have happened to that building in the near future?

In the particular instance above noted the designs were prepared by young engineers employed by the architect and who were paid remarkably well for their work. They were told to design in accordance with the requirements of a certain building ordinance, but evidently forgot their instructions. The offense in this particular instance is greater because the designers were employed by the architect and had no motive for attempting to do wrong. The plans showed the men had made a close study of the mechanics of reinforced concrete and were moreover good draftsmen. They fell down, as many fall, because of carelessness, caused by lack of experience such as may be gained only by years of responsibility and also because their minds were fixed on the reinforced concrete, not on the structure into which it entered as a material.

In the design of beams a liberal enough allowance for partition loads is seldom made. Something is always overlooked. The writer found in one design a lack of steel in the beams amounting to 15% or thereabouts. Upon calling the attention of the designers to the omission, they stated that they had forgotten to add to the steel schedule certain pieces D_2, or some such designation, and it happened that this did provide for the right amount of steel. The writer called upon the designers and found their notes were in such bad shape that nothing could be checked and found they had added the D_2 after his letter had been received. They upbraided the writer for not coming to see them when he first received the plans, something he could not have done, even if the spirit had moved him to do so, for the average man who sends in plans to be checked is in the habit of cutting the name and address of the designer off the sheets of blue prints. When men are careless enough to forget things and too lazy or indifferent to check over their work before sending it out of the office, the present tendency towards the use of high stresses should be fought.

About five years ago, building ordinances tried to limit the concrete stress to 500 lbs. per sq. in. and steel to 10,000 lbs. per sq. in. A number of associations and societies have endorsed a concrete stress not exceeding 650 lbs. per sq. in. and a steel stress of not more than 16,000 lbs. per sq. in. The writer has not examined a plan in the past two years in which the concrete stress was less than 700 lbs. and the steel stress less than 18,000 lbs. The majority of plans provide for 1,000 lbs. in the concrete and 20,000 in the steel; a few for 1,200 lbs. in the concrete and 25,000 lbs. in the steel. When men use such stresses and forget a large per cent of the load the wonder is that more buildings do not fail. In a set of plans examined last week the actual stresses were 1,742 lbs. per sq. in. in the concrete and 31,000 lbs. per sq. in. in the steel, although the designers stated that they used a concrete stress of 900 lbs. and a steel stress of 20,000 lbs. Concrete workers claim that concrete is a wonderful material and one can hardly doubt it after checking twenty plans and knowing that this number represents a very small proportion of unchecked plans used.

In obtaining loads on columns the most common fault discovered by the writer is the failure to add the weight of the beams and columns. That is, the designer commonly takes the assumed floor load on each panel, omitting any addition for beams. Then in going from floor to floor he omits to add the weight of the column on the floors above. This is a place where the design can be readily checked, but few men do any checking. The writer owes most of his checking work to the fact, however, that some men do check the sizes of footings and big errors show up in the footings. One architect a few weeks ago asked the designers for the data they had used in a certain design, and especially for the soil pressure assumed. The data sent in was vague, but the soil pressure was stated to have been 4,000 lbs. per sq. ft. The architect and one of his draftsmen had gone through the design carefully, using weights taken from standard handbooks and believed they had found the actual load on the soil to be considerably in excess of 5,000 lbs. per sq. ft. The plans were sent to the writer and he had to redesign the entire building, the soil conditions not warranting a load of more than 3,500 lbs. per sq. ft., whereas the actual weights showed the designers had imposed a load of almost exactly 5,500 lbs. They had forgotten to add the column weights, but had assumed a weight per sq. ft. of floor to allow for the beams. Instead of deducting a certain percentage of live load on each floor as the loads were carried down, the percentage was taken on the total load.

With all the false first assumptions, failures to correct weights after a trial design, added to forgetfulness of certain items and the use of high stresses, we must consider the effect of bending moment assumptions. Is it right to consider beams entering wall columns as continuous or partially continuous? Should the effect of eccentric loading on columns be considered? The writer has never found that it is with reinforced-concrete columns. If a beam enters a wall column and is considered to be continuous or partially continuous what effect does it have upon the eccentric loading of the column? If a column is avowedly eccentrically loaded and no provision for this is made in the design should we consider entering beams as freely supported or consider them as continuous or partially continuous because of the monolithic nature of the construction? A great many designers use $\frac{wl^2}{16}$, where conservative men might use $\frac{wl^2}{10}$ or $\frac{wl^2}{12}$. The writer has never in all the plans he has checked discovered that freely supported beams are considered, it being customary to take ordinary conditions as warranting the assumption of a partially continuous condition for bending moment because of the monolithic nature of the construction.

Under the conditions mentioned as obtaining in so many designs, it is to be expected that it is a grave question whether many columns possess such a desirable quality as is expressed in the use of the term "factor of safety." The writer was called once in the middle of the night to help a contractor who discovered that a hooped column in the basement of a new five-story building was apparently failing. When the writer reached the building workmen were busy setting braces on each floor close to the columns and using bottle jacks to straighten out the floors. After the loads were entirely taken off the column an examination was made which disclosed the fact that the column was carrying more dead load than the designer confessed to having estimated as a total load. The foundation happened to be on a soft spot and this was also a case where at the beginning of the work first class workmanship had not been secured. We braced the building and removed that column, replacing it with a steel column fireproofed and also spread the foundation very considerably. Within the past two years a similar experience was had with four basement columns. Such accidents are more apt to happen with hooped columns than with longitudinally reinforced columns, for the higher stress in a hooped column really means a lower safety factor. A great many designers design a hooped column by arbitrarily assuming about 1.3% of hooping steel and assume 1,000 lbs. per sq. in. stress on the concrete with 16,000 lbs. on the longitudinal steel. Some are not even so careful as that. It is common to use hooped columns in the basement and sometimes on one or two lower floors, with longitudinally reinforced columns on the upper floors. The hooped columns with the lower factor of safety are, therefore, used at the commencement of the work when the men are all new and the poorest quality of concrete is obtained.

The writer advises all architects and contractors to carefully check the sizes of footings when plans are received. The exact quantities and weights are easily obtained, and a mistake by the designer can be readily detected so far as the bearing on the soil is considered. For column sizes deduct from the diameter of round columns 4 ins. for fireproofing and multiply the remaining core by 1,500 to check the load. From a rectangular column deduct 4 ins. from each dimension and divide the resulting core by 730 to check the load. If the quantities do not check, the plans should be turned over to an engineer of experience to go through the design. In the beams the flange width times the depth to the center of the steel divided by 138 should give the area of the steel to balance the concrete, but this does not prove the design is right. Yet this is about as much as many men can do and very often such simple checks show an architect that something is seriously wrong.

The class of men doing this bad work is a class that joins eagerly in the discussion of minute details of reinforced-concrete design, to the neglect of the larger matters connected with structural design. The writer would suggest that when a discussion is again started on the subject of reinforced concrete it be switched to a discussion of structural design and the importance of knowing the exact load, or as nearly as possible the exact load to be carried, before figuring the size of the slab, beam, girder, column or footing. Until this is impressed upon designers as a very important thing there will be many more cases of dissatisfaction among architects, and it is well for engineers to understand that a great many architects are opposed to the use of reinforced concrete. They have had unpleasant experiences and do all that they can to dissuade owners from using this material.

Some of the bad designing is due to greed and a profound confidence in the material being able to give a good account of itself, despite careless design and careless workmanship, a fact observed by every man engaged in concrete work. Many designs are purposely skinned by men anxious to prove to owners that reinforced concrete is the lowest cost material to use in strictly fireproof buildings. The principal reason, however, lies in the fact that reinforced concrete as a building material is a fad just now and the country is overstocked with young fellows who have specialized in the mechanics of the material, but without sufficient experience in structural design.

They work for very low pay as draftsmen, and presumably designers, in the offices of steel companies for a while and then when pay is not advanced fast enough to satisfy them, or a dull period compels their employers to lay them off, they go to architects and owners and qualify as "concrete experts." Their experience in the offices of the steel companies may not have been in very responsible positions and it may not have been of a nature to develop judgment in the larger questions of design, and certainly has not been long enough to give them the training that comes only by many years of experience and "soaking in," which every middle-aged and old engineer and large employer of engineers knows is fully as valuable as a college education.

In every case the writer has been engaged upon in which the worst errors were discovered the designers had been out of school less than five years and had been engaged as draftsmen in the offices of firms or individuals specializing in reinforced concrete or engaged in the manufacture or sale of materials used in concrete buildings. The young men seem to be very careless in load assumptions and very particular indeed in the refinements of design of details, not always, however, getting the very best details.

Older men, on the contrary, even men oftentimes with little experience in reinforced concrete but with years of good experience in general structural work, are very particular about the loads going to beams, columns and footings and are apt to use low stresses. The details in many cases are not so superlatively good with older men as they are with the younger fellows, but the details of connections are generally better.

In checking over the designs of young engineers the writer is generally compelled to redesign, for the buildings are not strong enough to come under the head of "good practice;" while he generally passes the designs of older men and intimates to the architects that some slight savings in cost might be effected if a re-design is wanted. This is never done. If the building

is strong enough it is satisfactory, but if the checking proves it to be weak the architect always becomes nervous and requires that it be designed to do its work properly.

The writer does not want to be understood as trying to discredit young men. His intention is to give some of the causes for the many failures of reinforced-concrete buildings, these failures being reported so often as to compel us to believe they are facts. The principal reason is neglect to consider properly many important items that must be considered and this neglect is generally due to youth and inexperience. If young men will change in character and become as conservative as older men no one could criticise them, and in time they do acquire these very desirable characteristics, by which time, however, they resent it if people do not call them young. After all, then, the fault lies with the men who employ boys to do men's work at boy's pay. Perhaps here is the real seat of the trouble. It certainly is not due to the material, for it has been too well tried to lead us to believe it to be inferior to any material when properly handled.

Concrete-Lined Coal Mine Shafts of Annabelle Mine, Annabelle, W. Va.

By E. C. AULD.*

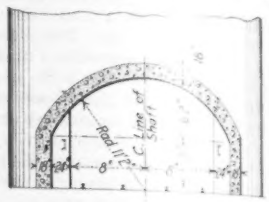
The surface plants of the Annabelle Mines are situated in the valley of Tevebaugh Creek, in Marion Co., West Virginia, about three miles above the town of Worthington and about 12 miles from Fairmont. There are two mines of an average daily capacity of 2,500 tons each. In opening them the company has spared no pains or expense to ensure the installation of the most improved apparatus and equipment. The hoisting and ventilating shafts were designed in conformity with this policy, being heavily lined throughout with concrete and containing no combustible material except the running guides. To add to the safety of the mines and to ensure their economical and continuous operation, a third opening in the form of a slope is added. This will normally serve the No. 2 Mine, but connections will be made so that it can be used as an escape way from No. 1 Mine. As the ventilating shaft is equipped with a hoist, there will actually be three openings at all times available from both mines.

The coal at this point is about 300 ft. below the surface. The hoisting shaft is 26 ft. 2 in. long and 11 ft. 6 in. wide inside, with straight and parallel sides and semi-circular ends. The air or ventilating shaft, 517 ft. away from the hoisting shaft, is circular, being 16 ft. in diameter and perfectly smooth inside. This form has distinct advantages, offering minimum resistance to the air current, and making the shaft easy to excavate as well as giving it greatest strength with least material.

The air shaft is equipped with a small headframe and steel safety cage running between four rope guides. The top is enclosed with brick walls and wooden roof and has a brick and steel air lock. The hoisting shaft has two cageways for hoisting in balance, the cages running between 6×8-in. yellow pine guides placed flat and supported at vertical intervals of 5 ft. by extra heavy steel channels. These are 12 in. deep and weigh 48.4 lbs. per lin. ft. These channels extend across the shaft and are embedded in the walls. While the action of the automatic safety devices on the cages, which suddenly transfer their weight to the running guides from the hoisting rope in case of failure of the latter, delivers heavy loads to these channels, the section is greatly in excess of the stress requirements. This excess section is added to ensure long life without replacement, and is believed to be a considerable economy.

Design.

HOISTING SHAFT.—Fig. 1 illustrates in detail the design of the hoisting shaft. The lining of this shaft was intended to be 13 ins. thick at the ends, this thickness continuing around the curved ends to the points of tangency. From here the sides were gradually thickened to 18 ins. at the center. These dimensions were specified as the minimum allowable, and it was intended to fill the irregularities of the excavation solid with concrete. However, owing to the large amount of clay encountered, [illegible] kept falling into the shaft, the actual thic[illegible] greatly exceeded expectations, as will [illegible] fully explained. The design called for [illegible] minal amount of reinforcing to care for irregu[illegible]ties of stress, but as the wall thickness was s[illegible]ch increased, the reinforcement was entirely [illegible]tted. It was not intended that the lining [illegible]d resist any considerable water pressure, rel[illegible] being placed on drainage. This is of inter[illegible] the light of the fact that some engineers h[illegible] advocated a mine shaft lining capable of r[illegible]ting a head of water equal to the entire dep[illegible] of the shaft.



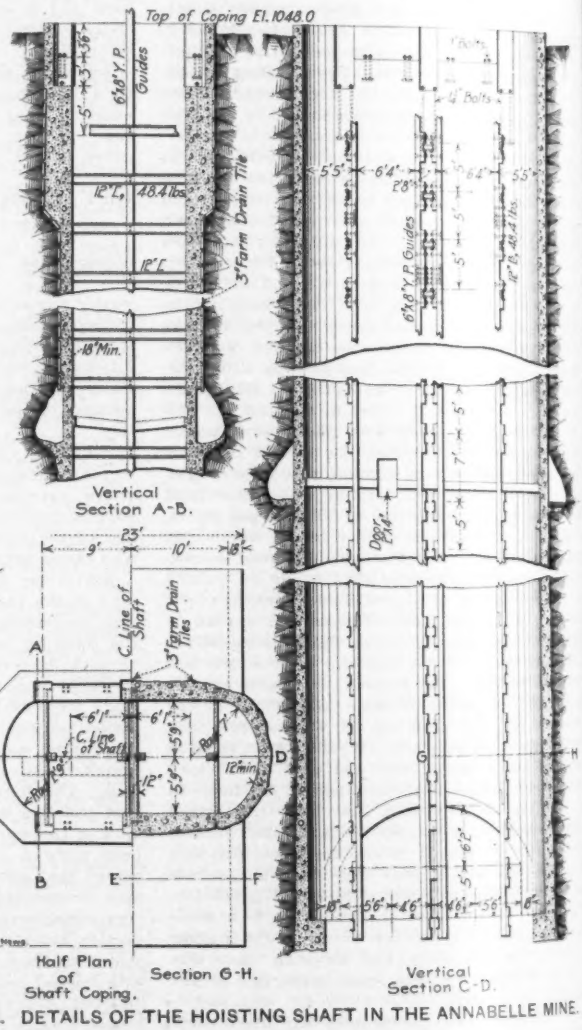


FIG. 1. DETAILS OF THE HOISTING SHAFT IN THE ANNABELLE MINE.

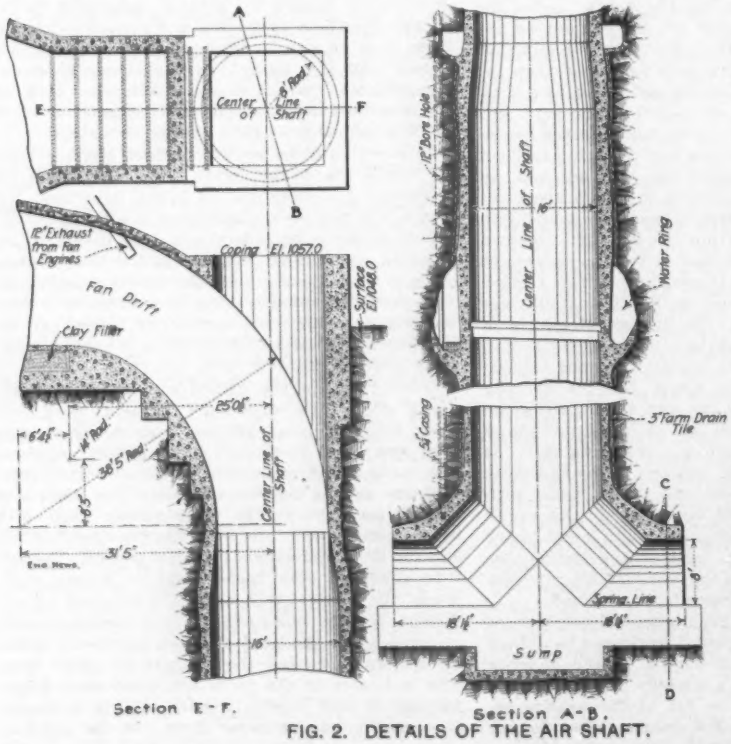


FIG. 2. DETAILS OF THE AIR SHAFT.

The excessive thickness and heavy reinforcing necessary to meet this requirement, particularly in a shaft of this size, would make the cost almost prohibitive. No doubt in some special cases where a heavy flow of water could be held above an impervious stratum at a reasonable depth, the sealed shaft would be economical on account of the elimination of a large amount of pumping which would otherwise have to be kept up throughout the life of the mine. But locations where this can be accomplished are rare indeed in the bituminous measures at least. As a rule, even heavy strata of limestone are sufficiently fissured to allow the water to flow into the workings so that it is doubtful if it is possible, even if desirable, to bring the pressure due to a head of several hundred feet of water on the lining.

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The top of this shaft is of interest, being somewhat of a departure from common practice. Most shafts, at least in the bituminous district of West Virginia and Pennsylvania, have been provided with heavy copings, being generally a thickening of the lining to 6 or 8 ft. and extending through the soil to the first rock stratum. Apparently these copings were designed on the theory that the sides act independently as retaining walls for the depth of the surface material. The Annabelle shafts, however, were thickened only enough to accommodate the recess for cage landers, and the base of the headframe columns; the Company's engineers believing that the tendency of this portion to collapse is no greater than, if as great as, portions in clay at greater depth. The surface around the shaft is well drained and the column loads even of the highest headframes are not sufficient to require extraordinary footings carried to rock. This is especially true where the columns rest directly on the lining itself, which, extending continuously for a great depth, can transmit enormous loads to the various strata.

AIR SHAFT.—Fig. 2 illustrates the design of the air shaft in detail. This drawing does not show the hoist and air lock. The latter is placed immediately above the top of the coping shown on Fig. 2. The shaft is connected to the horizontal drift of the ventilating fan with an easy curve. Below this connection, the section of the shaft changes from a 14 ft. square to a circle 16 ft. in diameter.

At the bottom, the shaft intersects the arched passageway of the main air course, the barrel of the arch being inclined upward at the intersection in order to reduce the resistance to the air current due to changing its direction.

Similar intersections were formed at the bottom of the hoist shaft. Here, however, the inclined portion is much shorter, being designed merely to accommodate long pipes and rails being lowered into the mine. The manway around the hoist shaft is cut through the solid coal and is not lined.

Construction.

EXCAVATION.—At each shaft the sump is only deep enough to accommodate the cage landing timbers and is drained to lower portions of the workings.

Both shafts were sunk and lined for a depth of about 70 ft., using a guyed derrick having a 40-ft. mast and a 60-ft. boom. When the shafts had been finished to this depth, temporary headframes were erected which were used until the shafts were finished.

The circular form of the air shaft was found to be particularly well adapted to economical excavation. From 12 to 16 holes about 12 ft. deep were drilled in a circle converging toward the center. They produced a sump about 12 ft. deep with a small bench all around. When the sump had been mucked out, the bench was shot with eight to ten shots.

Any necessary "pop shots" to trim up the sides were generally fired with the next sump shots. When the strata were liable to dangerous cracking, however, these pop shots were not fired until just before concreting, thus avoiding dangerous cracking above the men at work.

On account of the elongated shape of the hoist shaft, the end benches each required two rows of six to eight shots each, and the bench shots were as large as the sump shots. Another advantage of the shape of the air shaft was the fact that in the numerous beds of clay encountered the sides stood up much better than in the hoist shaft, particularly on the long straight sides of the latter. The caving in of these clays caused considerable trouble, and as no backfilling was attempted, all the space between the walls and forms being filled with concrete, the quantity of the latter greatly exceeded the minimum required by the design. The quantities per vertical foot shown on the design drawings inside the neat line were 9.6 cu. yds. excavation and 2.16 cu. yds. concrete for the air shaft; and 13.3 cu. yds. excavation and 2.93 cu. yds. concrete for the hoist shaft.

The actual average quantities for the air shaft were 10.7 cu. yds. and 3.24 cu. yds., an excess of 11½% and 50% for excavation and concrete respectively. For the hoisting shaft, these quantities were 15.6 cu. yds., being an excess of 17.3% for excavation and 5.28 cu. yds., an excess of 80% for concrete. These data were obtained from carefully kept records and are expected to prove of great value in estimating future work in this district.

The excavated material from the shafts was used in grading the railroad sidings within a distance of 400 ft. each way from the shafts. It was delivered in a dump car by gravity, and the top men pushed the empty back.

After the excavation had been extended to a certain depth, this portion was lined from the bottom up. When the concrete had set and the forms had been removed another length was excavated, this process being repeated throughout the work. It was intended to excavate about 50 ft. before concreting, but this depth had to be varied considerably in order to avoid starting concrete work in soft strata and also to so manage the work that while concreting was going on in one shaft sinking would be in progress in the other.

FORMS.—The steel forms used were designed and made by the Blaw Collapsible Steel Centering Co., of Pittsburgh, Pa., enough being supplied to completely line 25 ft. of each shaft. They were divided in vertical sections each 5 ft. high. The forms for the air shaft are shown in Fig. 3. As shown in the figure, the forms were of No. 10 steel plates stiffened with 5-in. channels and bound around the edge with angles. Each 5-ft. section was divided vertically into four segments, which when set up were bolted together by bolts passing through adjacent outstanding flanges. Each segment as placed was also bolted to the section below. The forms were braced as shown. These forms proved to be very satisfactory, being rigid and easily handled. They were in good condition on completion of the work.

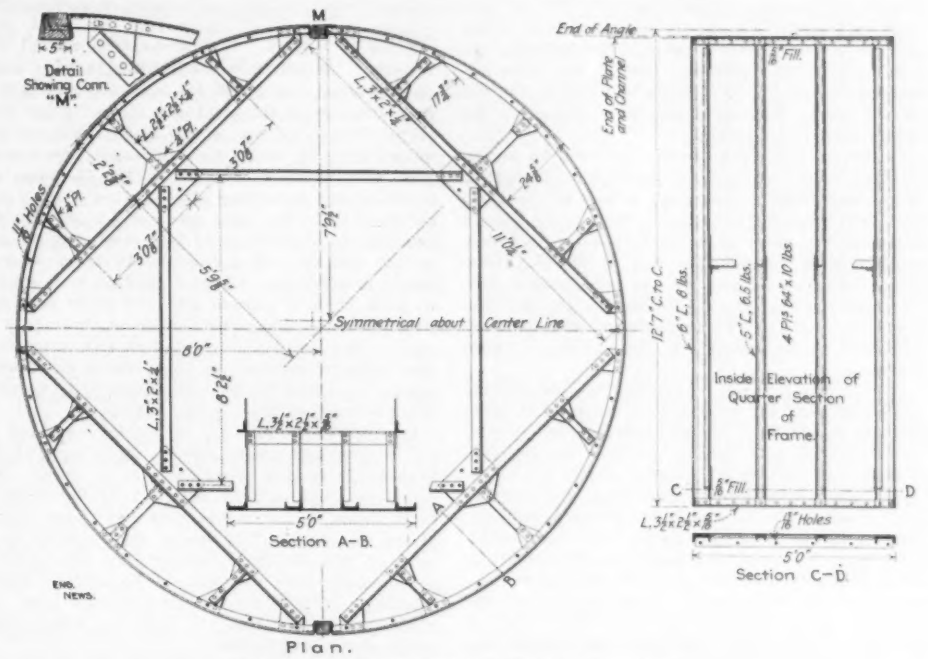

FIG. 3. STEEL FORMS FOR THE AIR SHAFT.

The first form for a "string of concrete" was placed as follows: the muck from the last bench

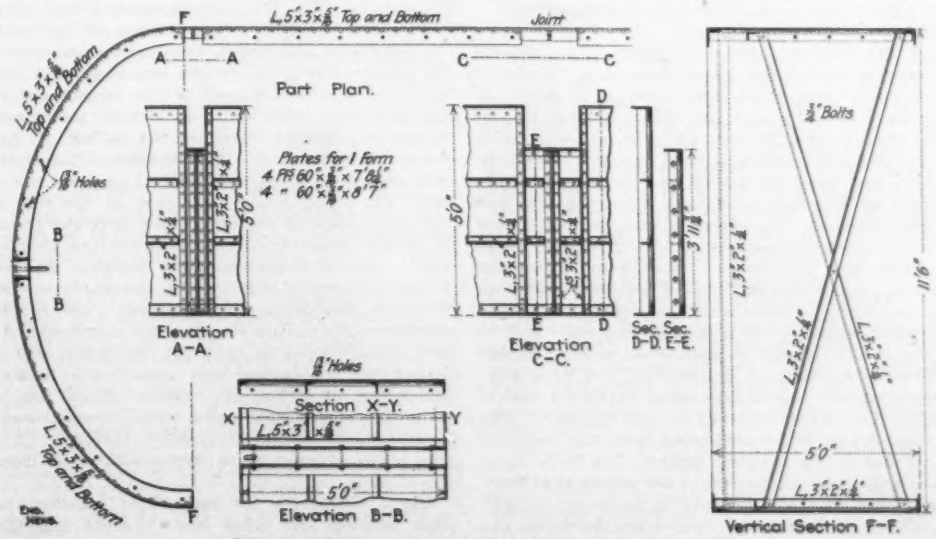

FIG. 4. STEEL FORMS FOR THE HOISTING SHAFT.

shots was leveled up and several 12 × 12-in. timbers laid across the shaft. On these was laid a narrow plank platform around the sides of the shaft. This was carefully leveled, the form assembled on it, the level being checked on the top of the form. The form was then spiked to the plank with track spikes.

In the air shaft the forms were lined by means of four plumb lines, each suspended opposite a ¾-in. bolt projecting through a hole in the form into the space for concrete. These bolts were 8 ins. long and were provided with a nut and cast washer each which were left in the concrete. These bolts served not only as markers for line, but held the four sections in place after the concrete had set and the braces had been removed preparatory to raising the forms to the next position.

In the hoist shaft, lining up was somewhat complicated by the presence of the steel buntons already mentioned. These were placed every 5 ft. vertically, and each 5-ft. form section was notched on the top to receive them. The buntons were provided with bolt holes in the web on the center line to receive the guide bolts later. The lining up was done as follows: two plumb lines were hung on the longitudinal center line of the shaft, and 2 ins. from the end buntons. These lines were suspended from the buntons above in order to avoid long lines. A horizontal line was then stretched across the shaft touching these two. The end buntons were then placed at right angles to this line, and 2 ins. outside of the plumb lines, with the center holes opposite the plumb lines. They were wedged in place and the notches in the forms filled with wooden blocks cut to shape and kept in stock. The center buntons were then placed by measuring from the end buntons.

The guides and guide blocks were all framed and bored on the surface from dimensions measured horizontally from plumb lines and vertically on a 300 ft. steel tape hung in the shaft. This work was done after the shaft was otherwise finished and when the guides were bolted up they were found to fit together nicely.

The cement, forms and buntons were hauled in wagons from Worthington, as the work was started in advance of the construction of the railroad. A quarry was opened in a good ledge of sandstone about 500 ft. from the shafts and this supplied all the sand and stone for the concrete. The ledge was about 18 ft. thick and required from 10 to 18 ft. stripping. The quarry was worked on a face about 250 ft. long. A crushing and screening plant having a revolving screen of 2¼ × ½× ¼-in. mesh and a dry pan for grinding the smaller sizes into sand was erected at the quarry and one mule delivered over a tramway all stone and sand used at both shafts. At each shaft a storage pile was made and this was added to during the periods of sinking. The quarry was run night and day and as concreting was never prosecuted in both shafts simultaneously, no difficulty was experienced in keeping the mixer supplied with aggregates.

A considerable quantity of cement was kept in two storehouses about 100 ft. from each shaft. Water for mixing concrete and all other construction purposes was obtained by damming a neighboring stream whose source is about a mile above the plant. This water was pumped to a tank on the hillside. During July and August considerable time was lost on account of water shortage. Even when all the pumpage from the shafts was turned into the lines, the supply was occasionally insufficient.

The materials were wheeled to platforms erected at each shaft, on each of which was mounted a continuous mixer. These machines were permanently connected up with steam and water lines and were not moved until all concreting was finished. The arrangements were such that the machines could be kept in continuous operation to their full capacity during concreting. They proved too light for the work, however, and gave considerable trouble from breakage. The concrete was delivered down the shaft in two ordinary sinking buckets, one being emptied directly behind the forms while the other was filling at the mixer. When the lower bucket was empty it was hoisted and placed beside the one filling at the edge of the platform. The buckets rested on two strips of sheet steel which were kept greased to facilitate moving the buckets. When a bucket was filled, the hook was removed from the empty to the full bucket, the latter was snubbed off the platform, steadied and lowered and the empty slid under the mixer delivery.

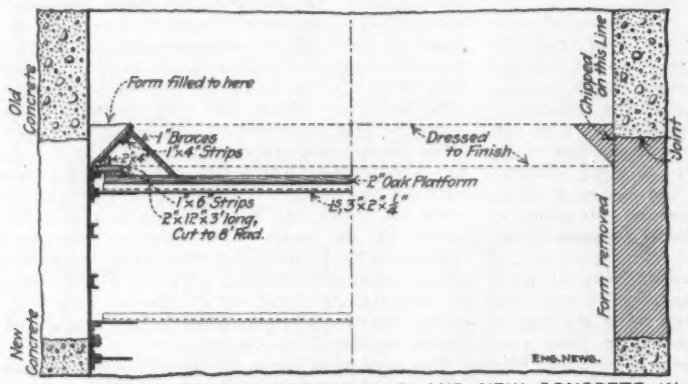

FIG. 5. METHOD OF CONNECTING OLD AND NEW CONCRETE IN THE SHAFTS.

At the hoist shaft, the temporary headframe was made wide enough for two sheave wheels, one over each cage way. On account of the middle buntons it was impossible to swing the bucket all around the form, so one end was filled first and the rope transferred to the second sheave for filling the other end. As already mentioned, owing to irregular blasting and falling of material into the shaft, the thickness of concrete was subject to great variation. In a great many cases the lining would be thicker on one side of the shaft than on the other; this gave the forms a strong tendency to move toward the thinner side. This was prevented by wedging wooden blocks between the form and the shaft on the thin side and filling that side first. The blocks were removed as the concrete reached them. At first it was tried to back fill the wider spaces caused by the caving clay strata, but it was found that no saving was affected. These spaces were, therefore, filled solid with concrete, containing large stones embedded therein. Care was taken to keep these stones well back from the form.

Fig. 5 illustrates the method of making the joint between the lower new concrete and the upper old concrete that had been in some weeks when the new string reached made with a wooden form trough extending entirely ar inner edge of this trough ex the old concrete, so that whe full of especially rich concre this 6-in. head caused the co under the old concrete. Aft set and the form been remov portion was dressed off, leavi This joint was the shape of a the shaft. The d 6 ins. above was filled level ixed very wet, le to flow well e concrete had the projecting he wall smooth.

DRAINAGE.—For drainage, eral lines of 3-in. farm tile were placed agai shaft. One man was kept placing these tile and spading concrete back the form. He placed broken stone around ea joint in the tile to prevent the concrete from unning in. The lines were placed as nearly as ssible under the points at which water appear in quantity and seemed to answer their purpo very well.

Above the Sewickley coal, ne 175 ft. below the surface, considerable tro with ground water was experienced, but ver little water was encountered below this level. The small amount that came in below this point was all carried off by the drain tile and caused no difficulty in placing concrete.

All the water was removed by one pump in each shaft running on compressed air. These pumps were kept on the bottom and drew their supply from a suction hose placed in a keg sunk in the muck at the center of the shaft. This prevented any large amount of sand from passing through the pump, and worked very well, as very little trouble was caused by the pump.

When concreting was started, the pumps were left on the bottom with valves open, so that they could be started by turning on the air at the top of the shaft. Until sinking was again resumed, at least 3 ft. of water was left on the bottom as a safety measure. Sometimes this water rose above the pump. The value of this precaution was demonstrated on one occasion. Four men pulled loose a plank from the platform on which they were working, and fell 35 ft. to the bottom The water broke their fall so that only one man was injured. He broke his jaw by striking the pump.

In the hoisting shaft a strong flow was encountered at a depth of about 35 ft. below the surface. The lining was not designed to resist any considerable hydrostatic head, so that the contractors' efforts to confine the water by inserting pipes and plugging them, only resulted in causing the water to break through the concrete at new points. The water was then drained by opening a large hole in the lining and digging a channel behind the lining to bring all the water to this hole. Here it was delivered into a 2-in. pipe leading down inside the shaft to the water ring. The hole surrounding the pipe was then filled with rich concrete and no further trouble was experienced.

In the air shaft it was desired to avoid the use of water pipes inside the shaft on account of the possibility of its being frozen in winter by the cold ventilating current. A 12-in. hole was drilled and lined with a 5¼-in. casing to the coal before sinking was started. This hole was located about 4 ft. outside of the shaft neat line.

The water was collected by water rings suitably located, and drained into this casing, which discharges into the sump at the bottom. Hose connections are also provided to this pipe, located in the roof of the barrel arch and designed to make the water available for sprinkling and in case of fire.

The construction of water rings is shown in Figs. 1 and 2. A projecting lip is formed in the lining to intercept the water flowing down the inner surface. Behind the lining, a passage is excavated entirely around the shaft. Its dimensions are such as to allow a man to crawl through it for the purpose of cleaning. A door is formed in the lining to give access to the ring. The rings are paved with concrete in the form of a gutter having a total fall of 6 ins. in half of the circumference. The water is delivered into the pipe through a cast-iron strainer, consisting of two perforated side plates and a top plate. In the hoist shaft a small pump operated by air was placed in the water ring to remove the water

CONCRETING.—Before beginning to deposit concrete behind the lowest form of a "string of concrete," the space was filled to a depth of about 2 ft. with sand and stone, in order to seal it, and prevent the concrete from running under the form and making it hard to draw. The 5-ft. form sections were placed and filled successively until all five had been used, when the first one was removed and placed above the last; thus each section was used twice in each string. Each section was provided with two pairs of wooden wedge blocks placed between adjacent segments and held by bolts through the vertical flanges of the segments. A ¾-in. eye bolt was fixed in one of the blocks of each pair and when the forms were ready to be removed, the bolts were removed and the wedges were drawn by means of a chain block attached to this eye bolt. The cross braces were unshipped and one segment attached to the hoisting engine. The ¾-in. bolts embedded in the concrete were unscrewed, leaving their nuts and washers in the concrete, and the segment was hoisted above and bolted to the last form placed.

during sinking. The ring was sometimes allowed to overflow in order to provide water for cleaning holes.

The bottom arches for both shafts were cast on sections of the shaft form, being purposely made of the same radius. The coal was first removed and the bench walls built. The roof was then shot down and the arch completed in 5 ft. sections.

The accompanying table shows the average time required to remove one 5-ft. form and place it higher up, and also the average time for concreting one 5-ft. section of form.

Table Showing Progress in Concreting.

	Hoisting shaft.				Air shaft.			
	Forms.		Concreting.		Forms.		Concreting.	
	hrs.	min.	hrs.	min.	hrs.	min.	hrs.	min.
1st string	11	0	8	50	9	0	4	55
2nd "	14	30	11	40	5	15	4	20
3rd "	9	0	4	40	3	35	3	30
4th "	6	30	7	30	3	55	5	10
5th "	5	45*	3	55				

*This includes placing only, as forms were on the surface and were merely lowered to place.

No forms were drawn until the concrete had set at least 48 hours. The work was so arranged that no appreciable time was lost in waiting for concrete to set.

Sinking at the air shaft required a total of 117 working days and concreting 34 days. Ground was broken at the air shaft April 5, 1910, coal reached Sept. 6, 1910, and concreting finished Sept. 19, 1910. The actual depth was 307 ft. At the hoist shaft 103 working days were required for sinking and 50 days for lining. Excavation was started April 15, 1910, coal reached Oct. 1, 1910, and concreting finished Oct. 15, 1910. The actual depth was 300 ft. The working day was divided into three shifts of eight hours each both for sinking and lining. On each shift were employed an average of ten men besides the shift boss and the hoisting engineer. Exactly the same force was used for concreting as for sinking. Three men and the shift boss were down the shaft handling concrete, three men were wheeling sand and stone to the mixer, one man ran the mixer, one handled cement, and one managed the bucket at the top. Only six of the ten were used to draw forms. No fatal accidents occurred on this work. The construction of these shafts was carried on by the Stewart Construction Co., of Pittsburgh, Pa., under the immediate supervision of Mr. E. F. Miller, General Manager of the Four States Coal & Coke Co., and the writer, Division Engineer. The general offices of the coal company are located in the Frick Building, Pittsburgh, Pa. Mr. D. G. Jones is President, and Mr. A. C. Beeson, Chief Engineer.

The Irrigated Area of Nevada increased from 204,850 acres in 1899 to 709,018 in 1909, or 40.6%. The total area of improved farm land increased 21.8% in the same period. The total cost of the irrigation systems reported in 1910 (not 1909) was $6,664,833, against $1,533,927 in 1899, an increase of 334.5%, indicating the relatively high-grade character of the later irrigation works. Of the area irrigated in 1909, 37,185 acres, or 5.2% of the total, were supplied from works built by the U. S. Reclamation Service.

The Connecticut Law Regulating Dam and Reservoir Construction was enacted in 1878, four years after the Mill River dam disaster in Massachusetts in which about 150 lives were lost. The first section of the law provides that:

"The member of the board of railroad commissioners, who is a civil engineer, and one civil engineer residing in each congressional district in this state to be appointed by him, shall constitute a board of civil engineers and have the supervision of all dams and reservoirs now existing, or hereafter constructed, in any locality where by the breaking away of the same, life or property may be in danger of destruction."

Under the third section of the law, the petition to local city or town officers of two or more persons who feel that they will suffer loss by the breakage of a dam or reservoir is to cause an official inspection by a member of the State Board of Civil Engineers above referred to. Under the fifth section, the engineer under whose authority a dam or reservoir is being built "shall cause the work on the same to be inspected at least three times before its completion."

Water-Purification Experiments on Removal of Taste, Odor, Color and Iron at Brisbane, Queensland, Australia.

Some interesting experiments on the removal of taste, odor, color and iron at Brisbane, Queensland, Australia, were reviewed at the annual convention of the New England Water Works Association at Gloucester, Mass., on Sept. 13, in a paper prepared by Mr. Hardolph Wasteneys. The author is now connected with the Rockefeller Institute of Medical Research, New York City, but was in local charge of the experiments described, which extended from 1904 to 1908.

In introducing the paper, Mr. Allen Hazen, M. Am. Soc. C. E., President of the Association, who was called to Brisbane in 1907 to advise the water authorities there, remarked that this particular water ranked in bad quality with the notorious Ludlow supply of Springfield, Mass., the Goose Creek supply of Charleston, S. C., and a number of the supplies in the Panama Canal Zone. The peculiar and complex badness of the Brisbane supply is due to heavy growths of fresh water organisms and other conditions described further on.

It should be stated that the water-supply in question is of surface origin, forms a portion, only, of the water-supply of Brisbane and is stored in the Enoggera Reservoir, which has a capacity of about a billion gallons and a drainage area of nearly 13 sq. mi. The drainage area "is for the most part fairly heavily timbered with eucalyptus with a large proportion of a comparatively dense undergrowth." The municipality controls the drainage area, permits no human habitations upon it and, in addition, patrols the gathering ground, "so that there is, practically speaking, no danger of bacterial contamination."

Summer and winter at Brisbane are reversed from our viewpoint. During 1906 the average daily mean shade temperatures at the experimental filters, which are close to the reservoir, ranged from a minimum of 54.8° F. for the month of July to a maximum of 77.7° for the month of January.

The methods of water-purification experimented with included (1) coagulation and rapid filtration; (2) intermittent filtration through coarse-grain percolating filters dosed with a revolving sprinkler with an automatic arrangement for intermittent working, the whole being called a Morry filter; (3) a Morry filter (as above) used as a roughing filter, followed by ordinary continuous sand filtration; (4) various slow sand continuous filters, some of which were combined with preliminary aeration; (5) the Anderson revolving process (chemical treatment with ferric hydrate, produced in the apparatus from scrap iron); (6) aeration, filtration and sedimentation which were applied to the bottom water of the reservoir, and (7) slow intermittent sand filtration, which was the method finally adopted for treating the supply from this reservoir.

The experiments as a whole were conducted "almost entirely" under the supervision of Mr. John Kemp, Chief Engineer of the Brisbane water-supply, and were in the immediate charge of the author of the paper from which our information is taken.

Character of the Water-Supply.

The peculiar conditions governing the character of the supply may best be stated in the words of Mr. Wasteneys, as follows:

There is only one overturning of the reservoir contents during the year, occurring about the month of May. This is due to the fact that the temperature of the water is never low enough to reach the point where water attains maximum density, which phenomenon, in a less mild climate, is the cause of a second overturning. As a consequence the water is stagnant, at depths below 19 ft., for 11 months out of the 12, and these conditions are very favorable to putrefactive processes. Thus, from a depth of 20 ft. downwards the water, except during the annual overturning, contains little or no oxygen and the iron contents show a corresponding increase. At 20 ft. from the bottom, at a place where the reservoir had a depth of 60 ft., the data at hand indicate iron in solution to as much as 50 parts per million.

The comparatively high and long-continued summer temperatures, the large proportion of shallows in the reservoir, the long stagnation period, strong light and high organic content of the water, are all in favor of an abundant growth of algae, especially the blue-greens, with their accompaniment of disagreeable odors and tastes, and this growth indeed takes place. The organism growing most abundantly is Clathrocystis, whilst Anaboena and Oscillaria are also often plentiful. The Diatom Synedra sometimes occurs in such quantity as to render the surface water quite opalescent and the Protozoa Peridinim is also frequently present in large numbers. The water has nearly always a moderately offensive odor, not always so noticeable at the reservoir itself, but more so at the consumers' end of the pipe. The trouble is augmented by growths of Plumatella, Cordylophora and Sponge in the mains.

Plumatella grows very densely in the pipes at the inlets to the service mains, and in the autumn, when it usually begins to decay, it becomes detached from the pipes and disintegrates, thus causing much additional trouble in the shape of a new variety of offensive odors and mechanical obstruction to faucets, meters, etc.

The water applied to the filters was taken at a point 5 ft. below the surface of the reservoir and about 180 ft. from the shore line in the deepest part of the reservoir, and was drawn through a 16-in. cast-iron pipe about 300 ft. long. The paper (which will be published in full in a future number of the Journal of the New England Water Works Association) contained a table giving monthly averages of analyses made during 1906, the samples having been "collected during a period of one hour at the inlets to the various experimental filters." We take from the table figures for some of the determinations only, and confine those to the maximum or minimum. All the figures are in parts per million. The free ammonia ranged from .02 for September and October to .06 for March and June; albuminoid ammonia, .21 for May and .35 for January. Total iron, .22 for January to .65 for May. Color, 22 for December and 80 for May, the first figure being based on the Platinum Cobalt standard and the second computed to correspond to that standard from results obtained with the Lovibond tintometer. The odor of the water (cold) was of a strong vegetable character for the first five months of the calendar year and very strong for March. For June it changed from distinct to nothing, while in July it was reported as nothing, and during the rest of the year ranged from slight to distinct and strong.

Nature and Result of Experiments.

COAGULATION AND RAPID FILTRATION.—Using alum and lime as coagulants, and with filtration rates up to 130,000,000 U. S. gals. per acre per day, "very satisfactory reductions of organic matter and color were effected." No records of removal of odors were made, but, as recollected by the writer, odors were not completely removed. A report favorable to this process was made by Mr. J. B. Henderson, Government Analyst, who arranged and supervised the experiments, but the local authorities did not appear to be "thoroughly convinced" by Mr. Henderson's report "probably owing to the suspicion with which the use of coagulants is, or was, regarded by British communities."

Intermittent Coarse-Grain Percolating Filters.

Various modifications of this filter were used after designs by Mr. C. A. Morry, "an official of the Department of Public Works in Brisbane." The so-called Morry filter is similar in principle to that of the Ducat sewage filter [which attracted considerable attention in England a number of years ago]. In some of the Morry filters experimented with, sand, and in others small coal, was used. One of the Morry filters is described in the paper as follows:

The filter is constructed with walls of dry stonework within a timber frame on a square plan and has an internal diameter of 9 ft. 4 ins. at the bottom and 8 ft. 2 ins. at the top. The walls rest upon a concrete bed dished towards the sides, which forms the bottom of the filter and serves to conduct the effluent into a concrete channel which constitutes the discharge.

The filtering material consists of 6½ ft. of screened gravel, a rough mechanical analysis of which gives:

100% finer than 8.5 mm.
51% finer than 6.0 mm.
23% finer than 4.0 mm.

Water is fed on to the filter bed through an intermitter of 20 gals. capacity from which it is discharged automatically, by means of a siphon, at intervals, into the hopper of a revolving

sprinkler which distributes it evenly over the bed through which it slowly percolates. Provision is also made for side aeration in addition to that derived from the loose-stone walls, by means of four lines of loosely jointed unglazed earthenware pipes placed within the filtering material and traversing the bed from wall to wall. During the time this filter was at work, over six years, nothing was done to the filtering material except to rake the surface at long intervals in order to bring it to a level.

A total of the monthly averages for 1906 obtained from Morry filter No. 1, composed wholly of gravel and working at the rate of from 2,300,000 to 3,100,000 U. S. gals. per acre per day, showed chemical results in parts per million as follows: Albuminoid ammonia, .13 in January, February and May as a minimum, and .18 in September as a maximum, but also with .17 for four other months of the year; total iron, .02 for July and .25 for November. Color on the platinum scale, 13 for October, November and December and 34 for May. During the first nine months of the year the turbidity was read as slight, and during the last three months as a trace only, all the readings being under five parts per million on the silica scale. Of 57 determinations for odor (cold) 44 showed no odor, four a slight trace and nine a trace.

MORRY FILTER AS A ROUGHING FILTER, FOLLOWED BY ORDINARY SAND FILTRATION.—It being evident that the material used for the filter reported on in the table just abstracted was too coarse, it was decided to use the same filter as a roughing filter as preliminary to ordinary continuous sand filtration. The final filter was composed of 3 ft. of river sand having an effective size of .28 mm. and a uniformity coefficient of 1.96. Working at a combined rate of 6,000,000 U. S. gals. per acre per day, "odors and tastes were effectually removed."

Table I. shows the results obtained from a Morry filter alone, while Table II. shows what was accomplished by the same filter in combination with a sand filter:

TABLE I.—AVERAGE COMPOSITION OF EFFLUENTS FROM AND PERCENTAGE REDUCTION EFFECTED BY MORRY FILTER NO. 3A, USED AS A "ROUGHING FILTER."

	57 determinations made during the period Oct. 3 to Mar. 31, 1907. Average rate of filtration 8.44 million U. S. gals.. per acre per day.		4 determinations made during the period April 1 to 14, '07. Aver. rate of filtration 17.8 mil. U. S. gals. per acre per day.	
	Parts per million.	Per cent. reduction.	Parts per million.	Per cent. reduction.
Free ammonia.....	.01	65	.01	73
Albuminoid ammonia	.20	30	.20	25
Oxygen consumed in 15 min.....	1.7	18	1.2	15
Oxygen consumed in 4 hrs.....	3.0	21	2.4	17
Iron (total).....	.23	38	.27	35
Dissolved Oxygen...	8.2			
Turbidity.....slight			slight trace	
Color (Platinum scale)*	25	39	15	42

61 observations of odor in the cold made during the above period gave the following:

Nil	14
Slight trace	12
Trace	7
Slight	19
Distinct	9

*The figures for color, in the above table and in the tables to follow in this paper, were obtained by computation from Lovibond tintometer "units" estimated in the Lovibond tintometer.

TABLE II.—AVERAGE COMPOSITION OF EFFLUENTS FROM AND PERCENTAGE REDUCTION EFFECTED BY THE COMBINATION OF MORRY FILTER NO. 3A. AND A SAND FILTER.

	38 determinations during the period March, 1906, to March, 1907. Average rate of filtration for the combination of 2.93 mil. U. S. gals. per acre per days.		4 determinations made during the period April 1 to 24, '07. Aver. rate of filtration for the combination 6.0 mil. U. S. gals. per acre per day.	
	Parts per million.	Per cent. reduction.	Parts per million.	Per cent. reduction.
Free ammonia.....	.01	69	.01	76
Albuminoid ammonia	.12	54	.11	56
Oxygen consumed in 15 mins.	1.3	31	1.0	27
Oxygen consumed in 4 hrs.	2.3	34	2.0	33
Iron (total)	.12	68	.11	73
Dissolved oxygen...	7.6	..	..	..
Turbidity	nil.	..	nil.	..
Color (Platinum scale) 13.0		54	5.0	70
Odor	nil.	..	nil.	..

SLOW SAND FILTRATION.—Tests of several ordinary slow sand filters gave "good and fairly uniform results," but were "slightly objectionable" in some respects and were not so efficient in the removal of odors and tastes as the combination of gravel roughing and slow sand filters already described, nor as the intermittent filter described further on.

CONTINUOUS SLOW SAND FILTERS WITH PRELIMINARY AERATION.—It being found that the dissolved oxygen in the applied water was "often nearly and sometimes quite exhausted in passage through the sand bed" during the warmer months of the year, aerators were applied to the inlets of the sand filters. By this means "almost complete saturation of the applied water" was effected. Nevertheless, nearly all of the oxygen was exhausted during the passage of the water through the filters. This suggested that it might be desirable to supply more oxygen "to the bacteria doing the work," and led to the trial of the intermittent sand filters, which are described later in this article.

ANDERSON PROCESS.—As many of our readers remember, this process consists in showering scrap iron by means of revolving iron cylinders through water being treated. The ferric hydrate thus formed acts as a coagulant, and after opportunity for this action the water is filtered. Experiments showed

that under practicable conditions the process gave no results comparable with sand filtration per se, but that, when the iron dissolved in the purifier amounted to as much as 80 parts per million the effluent produced by the filter working at a rate of over 6,000,000 U. S. gals. per acre per day was of very exceptional quality, a removal of about 80% of organic matter expressed as "Albuminoid Ammonia" and "Oxygen consumed," and about 90% of color being effected. This is a far better result than was obtained by any other process, but the method is, of course, quite impracticable on account of cost.

AERATION, SEDIMENTATION AND FILTRATION OF THE BOTTOM WATER.—These experiments resulted from a suggestion made by Mr. Allen Hazen in January, 1907, and took into account the fact that during a large part of the year the bottom water contains much more color, organic matter and iron than the surface water. It was thought that by this means the ferric hydrate in suspension could be made to act as a coagulant, much the same way as in the Anderson process. The experiments showed that

with liberal aeration and 48 hours settlement previous to filtration, it was possible sometimes to get a very satisfactory filtrate and at a rate of 6,000,000 U. S. gals. per acre per day, but the results were subject to considerable fluctuation and, usually, the filtrate contained considerable color and iron.

It was found most difficult to secure a complete precipitation of the iron hydrate, which was possibly suspended in a colloidal condition. The writer is by no means convinced, however, that, in the light of recent scientific research on the subject of the precipitation of colloids, this ingenious method of utilizing the coagulant provided in situ by nature, could not be successfully carried out.

INTERMITTENT SLOW SAND FILTRATION.—The desire to secure an additional amount of oxygen for use in the filters led to a trial of this process. Before describing the filter experimented with, the author stated what was expected and in general what was achieved by the process, as follows:

It was expected that the additional oxygen supplied for the oxidation processes by the intermittent application of water to the sand bed would result in an increased oxidation of the dissolved organic matter with a more complete removal of iron, tastes and odors. The results indicate that, through this method of operation, an increased amount of oxygen is undoubtedly supplied to the water in the sand bed, as the effluents always contained a considerable quantity.

An increased oxidation of organic matter also takes place though this is indeed quite slight.

The most satisfactory improvement is in the matter of removal of odors; this was most complete, as only on very rare occasions, even on warming, could the faintest odor be detected in the effluent from these filters, while it was always most palatable, the objectionable tastes of the reservoir water having been entirely removed.

A fairly detailed description of the experimental filter and a more specific summary of the results obtained than was given in the immediate foregoing quotation follow:

The following are particulars of the construction of this filter, quoted from a report made by the writer, to the Board:

The tank containing the filt[er] made of 18-gage corrugated galvanized-iron ... ft. 10 ins. in diameter, and has an effective ... of 75.97 sq. ft. It is 10 ft. in depth. The u... drains consist of a brick arch composed of ... y laid bricks with very wide joints extending ... ss the middle of the tank to the outlet. Thi... h is covered with 1½-in. gravel, which is 1... s. deep at the sides of the tank away from the ... h and rises in the center to just cover the bri... Over this is placed 3 ins. of ¾-in. gravel, th... ins. of ¼-in. gravel, 2 ins. of ⅛-in. gravel, a... ins. of coarse sand (effective size 4 m.m.). T... finished layer presents the same sloping appe... ce as the first gravel layer.

The filtering medium is com... of 3 ft. of sand obtained from the Enogg... Creek, having an effective size of 0.27 m.m., ... finer than 0.69 m.m., and a uniformity coefficie... of 2.5.

The water is led on to the filter ... through an iron pipe and falls into an iron tro... placed 2 ins. above the surface of the sand. ... trough is 12 ins. wide and rests on baffle plate... extending 6 ins. on each side to effect an even d... tribution of the water. The exit is through a hori... ntal pipe level with the bottom of the tank.

The filter was started on Jun... 27, 1906, with a rest interval of 4 hours in 24; between that date and Jan. 7, 1907, when the meth... of application was altered, raking to remove surface choking was necessary seven times. The average quantity per acre filtered between raking... was 70,000,000 U. S. gals. and the rate of filtration averaged 2,800,000 gals. per acre per day. From Jan. 12 until Feb. 15, water was applied at intervals of 1½ hours, 6 ins. being delivered in three minutes at the commencement of each interval; this caused the filter to choke very rapidly.

On Feb. 16 the interval of rest was increased to 8 hours in 24 and on Feb. 19 the rate was increased to 6,000,000 gals. per acre per 24 hours. The filter required raking on Feb. 25 and March 12 and 22; in July of the same year the records at hand show that the filter had been given no further raking and showed no signs of further choking.

The author stated in conclusion that a filter similar to the one just described, and at the same time following the lines of the Ludlow filter at Springfield, Mass., was recommended for the treatment of the Enoggera Reservoir water by Mr. Hazen in 1907. The filter as recommended, the author understood, has practically been completed.

Referring to the paper at the time of its presentation, Mr. Hazen stated that the results attained in the various experiments were all commendable, and that had not the results with the intermittent sand filters been so much superior to the others, any of the others would have been regarded as very favorable.

Original Work in Machine Design for Students of Mechanical Engineering.

By WALTER RAUTENSTRAUCH,* M. Am. Soc. M. E.

In the year 1858, when the modern science of mechanical engineering was young, a great engineer and teacher took occasion to write the following words in explanation of the characteristic attitudes of men laboring in the sub-divisions of science which are usually termed the "theoretical" and "practical." "In theoretical science the question is—What are we to think?—but in practical science the question is—What are we to do?"

Great as have been the advances in engineering instruction since Prof Rank...e's time, there nevertheless still lingers in some quarters a failure to appreciate that the young men passing through our engineering schools are to be constructive rather than contemplative beings. But this failure to gain a true perspective is rapidly disappearing among those who are teaching the technical subjects in our engineering schools. Particularly is this true in the quarters where the professors are in vital contact with engineering enterprises. It is generally appreciated that although the student's knowledge of a wide range of subjects may be limited, his ability to *produce* something with what information he possesses is of the greatest importance. Consequently it will be noted that the technical courses of instruction in our schools are being planned with a view of developing the student's productive capacity.

Of the many subjects taught in our schools, those grouped under the head of Machine Design lend themselves most favorably to this mode of treatment. In this particular field of engineering practice there has been developed a great body of tried and proven types and forms of con-

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struction adaptable to a wide range of conditions of service, the mere copying of a few of which was considered, in times past, a sufficient drill in machine design.

The more modern and effective method of treating this subject, however, contemplates the exercise by the student of his knowledge of the underlying principles of construction in these standard forms and types, through their incorporation in some design which the student attempts for himself. By this it is not meant that the student is required to produce any original invention in machine design but rather to use the plain, everyday facts learned in the class room and through contact with the machinery in the laboratory and shops in the design of some standard piece of apparatus.

It is with pleasure, therefore, that the writer has studied the work which Prof. Follows of the Carnegie Technical Schools of Pittsburgh is doing with his students of the Junior Class. We have before us a problem given to these young men, which illustrates the nature of the work.

Last spring Prof. Follows gave to the members of this class, some thirty in number, an original problem in machine design, viz., to make working drawings of a large high-duty cylindrical bearing.

During the summer vacation the designs made by these young men were forwarded by Prof. Follows to Engineering News and were by that journal submitted to the writer for study and comment.

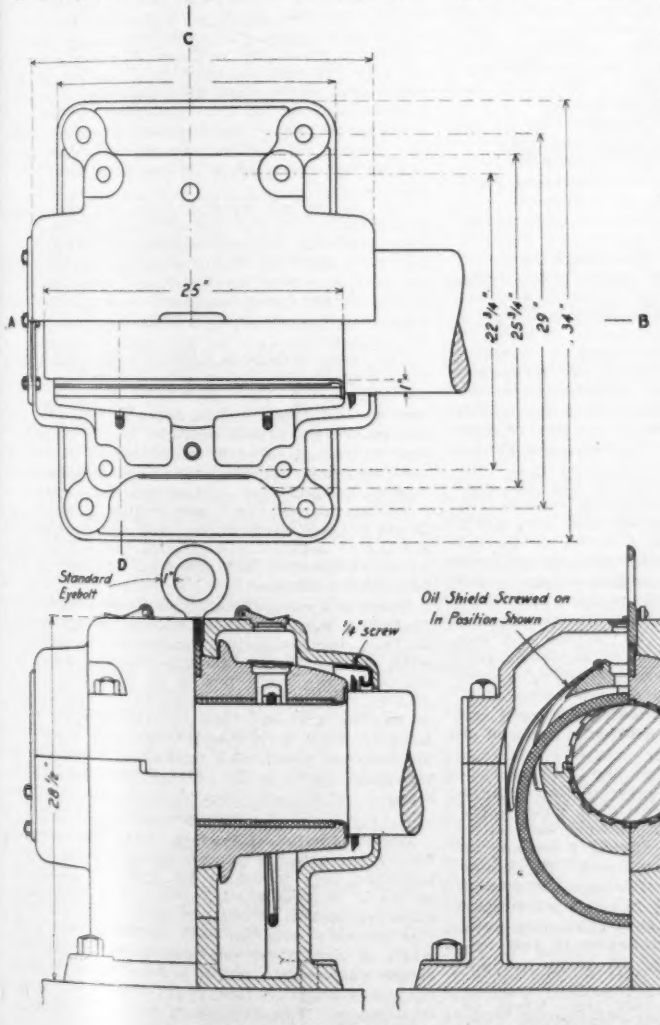
In giving out this problem to the students, Prof. Follows gave them a specification of the conditions which the design was expected to fulfil about as follows:

It is required to design a large high-duty cylindrical bearing to satisfy the following conditions: Diameter = 9 ins.; length = 24 ins. Horizontally split, self-alining, ring oiled, load to be 150 lbs. per sq. in. of projected area and vertically down. To be suitable for bolting down to a horizontal bed plate with a suitable number of bolts. Design to be approximately symmetrical about center lines of journal. To take moderate thrust in one direction from shaft shoulder. The "step" bearing proper is to be lined with babbitt metal of suitable thickness. Auxiliary safety seat may be supplied. Oiling to be done by two brass rings of suitable section and diameter which must dip into an oil reservoir of suitable capacity. There must be no leakage of oil from any part of the bearing. The cap must lift off and there must be inspection holes (with covers) to inspect the oil rings and oiling. The self-alining feature must permit the step to accommodate itself to the exact position of the journal so as to as nearly as possible give uniform pressure distribution in film. High-grade machine work may be called for.

With these instructions the students were taken to several shops where bearings were made, particularly the Westinghouse Electric & Manufacturing Co., to gather ideas and formulate a program for the design. No drawings from which copying could be done were given the students and their only sources of information were the visits to shops and instruction over the actual construction of bearings similar to the one to be designed.

An examination of the several designs which the students made shows that in nearly each case the student grasped the essential things in the design and was able to handle them in a fairly good manner. The designs of Messrs. Henderson, Lamoree and Riedel showed a marked degree of ability, not only in getting up a satisfactory design but in putting it out in a workmanlike fashion. It was impossible for the students to give evidence in this design of all the things they learned in these inspection trips; but the things learned with reference to this particular problem were well recorded.

The essential things accomplished in this design were the exercise of productive capacity and bringing the student to realize that the design of a simple machine element from the functional standpoint was a really good problem in design. Such instruction as this is also sure to give the student a correct appreciation of the importance of little commercial details in construction which are apt to be passed over unless emphasized as in this case.



ASSEMBLY DRAWING OF HIGH-DUTY BEARING.

Scale of original, ⅛ full size: Reduced ⅛ from original.

Designed and Drawn by J. K. Lamoree '12, Carnegie Technical Schools, Pittsburgh, Pa., April 10, 1911.

(Complete set of drawings included detail drawings, fully dimensioned, of Step-Base, Step-Cap, Housing Cap, Housing Pedestal End Plate and all small detail parts including bolts.)

Six Months' Financial Operating Results of the Garbage-Reduction Plant of Columbus, Ohio.

Reliable figures of cost of garbage disposal in the United States are few and far between, although garbage-reduction plants are in use in many of the larger cities of the country. Since the purchase by the city of Cleveland, O., of the reduction works treating the garbage of that city, figures showing half-yearly results have been published, but these cover only a few years. All the other reduction works, until a year or so ago, were in the hands of private companies, which kept their financial results to themselves. The operating results of the works at Columbus, O., just made public, are particularly welcome.

The municipal garbage-reduction plant at Columbus was put in operation in 1910 (see Eng. News, Nov. 17, 1910, for detailed description). This plant has a working capacity of 80 tons in twelve hours, or 160 tons per day if run full time. The garbage is collected by the city with its own force of men and teams and is shipped to the reduction works by rail. At the works power hoists lift the garbage to a drainage and sorting floor, from which it is shoveled into a scraper conveyor which takes it to digesters. In the digesters the garbage is cooked by steam under 60 to 70 lbs. pressure for from six to eight hours. The resulting tankage is passed through continuous roller presses and revolving cylinder dryers. The grease and water from the digesters go to separating tanks and the grease from these to treating tanks for the removal of impurities. A percolating plant is now nearing completion which will remove grease now left in the tankage by the process as originally installed.

A report of some twenty pages, describing the plant briefly and giving the financial operating results for the first six months of 1911, has just been made public. The report was prepared by Mr. Irwin S. Osborn, Engineer in Charge of Design and Construction of the plant, who, we understand, is also in charge of operation.

Altogether, the city has spent $295,531 for the reduction plant and for collection equipment. Of this sum, $189,542 went into the reduction plant, and $88,444 into equipment for the collection department, including loading station, site and buildings, railway siding, garbage wagons and garbage railway cars. General expenses apparently common to both the collection and reduction departments totaled $17,545, of which $16,143 was spent for engineering and $1,401 was charged to "office and advertising." We quote that portion of Mr. Osborn's report dealing with the operation of the reduction works:

> The reduction works have been in continuous service since July 20, 1910. As the works were new and men not acquainted with operation during the first few months of operation, we have taken the first six months of 1911 as more representative of what results can be obtained.
>
> During this period accurate records were kept of the operation and cost computed for each part of the operation. The following gives the amount of garbage disposed of during the first half of 1911, cost of disposal, amount of by-products recovered and the receipts received from sale of same:

GARBAGE RECEIVED.	Tons.
January	1,063.08
February	977.64
March	1,114.75
April	1,175.22
May	1,364.05
June	1,371.39
Total	7,066.13

The above includes 94 dead horses and 9 cows.
Number of days plant was operated, 155.
Average tonnage per day, 45.95 tons.

RECEIPTS.	
206.48 tons of grease	$21,413.92
1,132.03 tons of tankage	10,338.42
92 hides	253.90
Miscellaneous	1.50
	$32,007.74

INVENTORY JUNE 30, 1911.	
43 tons of grease at $100	$4,300.00
156.34 tons tankage at $10	1,563.40
34 hides at $4	136.00
	$5,999.40
Total receipts including inventory	$38,307.14
INVENTORY JAN. 1, 1911.	
68.44 tons grease at $108	$7,391.52
100 tons tankage at $10	1,000.00
	$8,391.52
Net receipts from by products recovered from 7,066.13 tons garbage	$29,615.62
EXPENDITURES.	
Supervision and payrolls	$9,724.03
Coal	2,349.75
Electric power	843.90
Repairs and renewals	849.24
Supplies	548.13
Office expense	185.78
Miscellaneous	191.84
Unpaid bills July 1, 1911	839.52
	$15,532.19
INVENTORY COAL AND SUPPLIES JULY 1, 1911.	
250 tons coal at $1.30	$325.00
Pipe, fittings, supplies, etc	200.00
	$525.00
Total net cost of disposal	$15,007.19
PROFIT OVER COST OF DISPOSAL.	
$29,615.62 less $15,007.19 equals	$14,608.43
Net revenue per ton of garbage	$4.19
Net cost per ton for disposal	2.12
Profit per ton	2.07

The plant has a capacity for disposing of 160 tons of garbage in 24 hours. In disposing of the 45.59 tons per day, the majority of the work was done during one eight-hour shift. During the second shift only such work was done as required more than eight hours. If the tonnage of garbage was sufficient to operate the plant at full capacity the cost per ton would be decreased as the same number of men are required to operate the machinery irrespective of the tonnage to be disposed of.

The total amount of tankage produced during the six months was 1,188 tons. Each carload was analyzed for determining the fertilizing elements on which the price per ton is based, also for the percentage of grease left in the material. From analysis the percentage of grease left in the tankage was approximately 10%. If the percolating plant, which is now under construction, had been in operation, a recovery of 8% of grease would have been made, which would have amounted to 95 tons, valued at $9,500. The operation of the percolating plant would have required an additional expense of $2,000, leaving a net revenue of $7,500.

The total cost for the collection of garbage for the first six months of 1911 amounted to $17,795, so that with the percolating plant operating the receipts from garbage would have been $4,313 over and above the cost of collection and disposal.

The grease output was 2.91% and the tankage output 16% of the green garbage.

It should be noted that the figures given relate wholly to operation, and take no account of capital charges on the investment of $189,542 for the reduction works. Taking collection as well as reduction equipment into account allowance would have to be made for capital charges on a total investment of nearly $300,000. We do not mention these facts to belittle the results reported, which are praiseworthy, but to save any one from thinking that garbage utilization, as it was formerly called, gives a net profit above combined cost of collection and treatment, if indeed there is a net profit on handling the garbage when delivered at the reduction works without charge.

Bureaus of Municipal Research have been organized in eight cities. These bureaus are supported entirely by voluntary contributions. The names of the cities and the dates of organization are as follows: New York, 1906; Philadelphia, 1908; Cincinnati, 1909; Memphis, 1909; Chicago, 1910; Fort Wayne, 1910; Westchester, N. Y., 1910, and Hoboken, 1910.

A Topographical Map of Maine is being prepared by the Geological Survey and the State of Maine, acting jointly. The scale is such that the map when completed will be 32 ft. high by 20 ft. wide. On account of this large size, the map will be published only in the familiar quadrangle units of the Geological Survey, 1/16 of a degree of latitude and longitude, or about 215 sq. miles. Already 27 quadrangles have been surveyed and the maps have been published. The area covered is mostly in the southern part of the state.

Cable Inclines of the Mayari Iron Mines, Cuba.*

Of the several extensive deposits of brown iron ore in Cuba, that of Mayari was the first to be systematically explored, and was selected as the scene of the first operations in the development of this class of ore.

Construction work, begun in the spring of 1907, involved the building of 16 miles of standard-gage railway and two large double-track inclines, the installation of mining machinery, a nodulizing plant, power plant, shops and shipping facilities, and the dredging of an extensive basin for deep-draft vessels. Unusual weather conditions delayed the completion of portions of this work so that the entire plant was not in operation until December, 1909.

The ore lies on an irregular plateau about 15 miles long and 5 miles wide at the widest point. The elevation at the northern extremity, which is approached by the railway, is about 1,700 ft. above sea-level. At the southern end the general elevation is about 2,000 ft. Ore is removed by means of scraper bucket excavators and steam shovels, these machines loading into special standard-gage, side-dump steel cars of 100,000 lbs. capacity. A short haul brings these cars to the head of an inclined plane, 6,800 ft. long, and of grades varying from 6 to 25%. From the foot of this upper incline there is a short railway about a mile long to the head of a second incline, 1,950 ft. long, and of 25% inclination. This lower incline ends in a gravity yard at an elevation of 130 ft.

The ore is therefore lowered by the inclines and connecting railway through 1,491 ft. vertical height, from elevation 1,621 to elevation 130; the track distance being 2.44 miles. Both inclines are double track, 14 ft. c. to c. Empty cars coming up on one track partly counterbalance loaded cars descending on the other track.

The main cables, 3 ins. diameter, pass over heavy drums, 20 ft. diameter, at the head of each incline. Each end of the cable is securely fastened to a "barney" car, against the spring buffer on which the ore cars rests. The speed is controlled by a steam engine geared to the drums, and by post brakes operated by steam.

From the gravity yard at Piedra Gorda at the foot of the lower incline, ore is carried over a single-track standard-gage line, 13.45 miles long, to Felton, on Nipe Bay, where a nodulizing plant for drying and sintering the ore is situated.

The depth of ore is not uniform, in many places the underlying rock projecting far up into the ore, even to the surface. The general slope of the ground, even in the most nearly level places, is quite irregular. Therefore, it is difficult to find many places where it is possible to operate a steam shovel for an extended period in a cut of economical depth, without including a considerable portion of the rock with the ore excavated. For this reason the scraper bucket excavators are more satisfactory as well as more economical for excavation, although their capacity is considerably less than that of the large-size shovel used.

As the machine works uphill or downhill continually, and the track alongside follows the same grade, cars can be dropped down by gravity to be loaded as needed, with a minimum amount of locomotive service. Three locomotives serve the shovel and excavators, and deliver cars to the head of the upper incline. Here the tracks have grades arranged so that cars, when the brakes are released, will run to the incline and the empties coming up will run off on another track. At present two cars are lowered over the incline at once, although three cars may be so handled. A brakeman travels up and down with each car to control the brakes at the beginning and end of the trip.

Both inclines are operated on the tail-rope system, the main cable on the upper incline being 3 ins. diameter, with six strands of 19 wires each, of plow steel, with a 1⅛-in. independent wire-rope center, the latter also having 6 strands of 19 wires twisted around a hemp core. Its breaking strength is estimated at 377 tons. The total length of this cable is 7,810 ft.; and its weight exceeded 123,000 lbs. The successful manufacture, transportation and installation of this unusual cable is a feat worthy of notice. Along the track, at frequent intervals, rollers, 10 ins. diameter, for supporting the cable. These rollers, turned from well-seasoned native hardwood, are carried by a 1½-in. axle which runs in simple hardwood bearings spiked to two ties.

At the upper end of the incline the cable passes over two drums, 20 ft. diameter, set tandem, both carrying heavy gears which mesh with a common pinion, 58.5 ins. diameter on a center line between the drums. Three and one-half turns are made over each drum by the cable. The pinion-shaft is also the crank-shaft of a pair of 30 x 30-in. vertical engines which are used in accelerating the moving parts and to carry the cars over certain parts of the incline where the descending loaded cars are on too low a grade to pull the empties up a steeper grade. On each drum are two pairs of post brakes operated by steam, the load being applied by a weighted lever acting through an eccentric.

The surface of the drum is lagged with hardwood for the brakeshoes to act upon. Grooved wooden lagging is also used on these drums for the cable to pass over. The drums are carried on a shaft 24 ins. diameter in center, with bearings 21 ins. in diameter. The construction of the drums and machinery is very massive, steel castings being used for almost all parts.

The machinery house is 221 ft. back from the head of the incline in order to provide for the crossover tracks from either incline track to load and to empty track. Spring switches are used, except one, which is free, being thrown by empty cars coming up to the correct position for the next loaded cars going down. Safety switches are located on the mine railway and at the head of the incline, to prevent damage by cars running away.

The contour of the upper incline, starting from the top, is as follows: 582 lin. ft. on 25% grade, 2,175 lin. ft. on 17%, 1,917 lin. ft. on 6%, 1,829 lin. ft. on 25%.

At the foot of the last slope the contour ends in a parabolic vertical curve 700 ft. long, connecting the 25% grade with the 1.4% grade. An indicator in front of the operator in the machinery room shows the position of the cars during the trip. In addition there is a complete electric bell signal system and an independent telephone line to provide for communication between the top and bottom of the inclines. The main rails one incline are 100-lbs. per yard. Between these is a barney-car track of 36-ins. gage, using 56-lb. rails.

The connecting railway from the foot of the upper incline to the top of the lower incline is arranged with suitable crossover tracks so as to facilitate handling the cars up and down by one locomotive, which is of the same type as those used on the mine railroad. Gravity tracks at both ends provide for handling cars to and from the inclines.

The lower incline is 1,950 ft. long, with a uniform 25% grade, ending at the bottom in a long vertical curve. The cable is of the same diameter as the upper incline cable in order to keep the machinery details uniform, but as the length and weight of cable is much less, it is made of cast steel instead of crucible steel, and has hemp center instead of an independent wire rope.

At the foot of the lower incline is the Piedra Gorda gravity yard, where loads are made up into a train by gravity, and empties, taken from train by a switchback arrangement, are run to the foot of the incline.

The main line railway from Piedra Gorda yard to Felton is single track, with 90-lb. Am. Soc. C. E. rails, laid on native hardwood ties, ballasted with stone. The locomotive which handles the trains on the main line is of the consolidation (2-8-0) type, with cylinders 19 x 24 ins., capable of hauling a 45-car train of ore, weighing about 3,200 net tons, from Piedra Gorda to Felton. The maximum grade is 0.5% in favor of loads, and the maximum curve is 6°. All bridges are built of steel.

*This description of the cable inclines is taken from a paper on "The Mayari Iron Mines in Cuba," by Mr. James E. Little (Steelton, Pa.), Mechanical Engineer of the Spanish-American Iron Co. The paper was presented at the meeting of the American Institute of Mining Engineers at Wilkes-Barre, Pa., in June, and is printed in full in the August number of the "Bulletin" of the Association (29 W. 39th St., New York, N. Y.).

The Production of Pottery in the United States for 1910 reached a record output of $33,784,678, according to a report by Mr. Jefferson Middleton, of the U. S. Geological Survey. The products as classified consist of red earthenware, yellow ware (for culinary utensils, etc.), cream-colored ware, white granite ware, semi-porcelain and semi-vitreous ware, china, sanitary ware (such as tubs, etc.), and miscellaneous art, chemical and industrial wares. The product of most importance is the white ware, although produced in only eight states; the value of this class of product was $14,780,980. The proportion of domestic products in all classes of pottery to total consumption is now 77.08%, compared with 15% in 1875.

Cable Incline Railways.

The term cable incline is applied usually to lines of short length and steep grade which are operated by cable traction, and lines of this class are much more numerous abroad than in this country. There are a few such lines, however, in Colorado, the Catskills and at Lookout Mountain (Tennessee), Mount Royal (Montreal), etc. In Pittsburgh and Cincinnati, also, there are cable inclines for the transportation of passengers, wagons and street cars from the lower to the higher sections of the city. Railways of this class in Europe (both for tourist traffic in mountain districts and for regular traffic in or near cities) are of sufficient number and importance to warrant the preparation of a book on this branch of engineering work; such a book was published nearly 20 years ago by a French engineer, and its second edition has just appeared. This book* (which deals also with cable street railways and aerial tramways) was reviewed in our Engineering Literature supplement Sept. 14, but from it we have compiled the following matter relative to cable inclines as likely to be of interest to our readers.

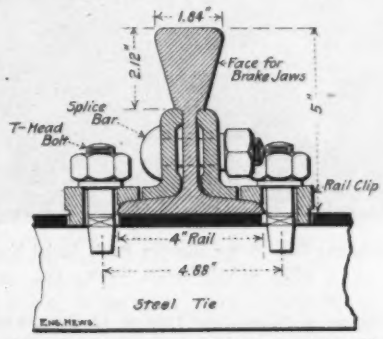
In a few cases the cable incline is operated by an endless cable, but the great majority of cable inclines have two cars attached to the opposite ends of a cable which passes around drums or pulleys, at the head of the incline. Under this system the movements are alternating, one car ascending as the other descends. Cable inclines operated on this alternating system are of three classes: (1) Those in which the driving drum or sheave is operated by an engine or electric motor; (2) Those in which the descending load is always in excess of the ascending load and may be used to operate the line by its excess weight. (3) Those in which the descending load is given an excess weight by means of a tank on the car, the tank being filled at the top and emptied at the bottom of the incline. Lines of the first and third classes are numerous, but those of the second class are limited and are confined mainly to serving mines and quarries.

With a cable incline no very great variations in grade are practicable; stretches of level track must be short and sags in grade must be avoided. In alinement, also, very little curvature is permissible, and reverse curves must be avoided as far as possible, owing to the difficulty of guiding the cable. The tension on the cable is variable, due to the action of the operating drum, the changes in speed, and the varying weight of cable between the car and the drum. The result is that the cable oscillates in a vertical plane; when jumping off the carrying pulleys on a straight line the cable naturally falls back upon the pulleys, but on curves there is liability of its becoming displaced. In addition to this, the obliquity of the line of traction causes wear of the pulleys and wear and abrasion of the cable.

The minimum grade is that which will cause the descending car to put sufficient tension on the cable. This rate of grade is not constant under all conditions; it depends upon the length of the grade, its position in the profile and the momentum of the cars in passing it. A number of lines, especially those operated for freight alone, have grades connected by short stretches of level, over which the cars run by their momentum. The maximum grade is very high, and some of the steepest lines have maximum grades as follows: Territet-Glion, 57%; Burgenstock, 58%; San Salvator, 60%; Treport-Terrasse, 6%; and Virgl, 70%. All these are exclusively passenger lines, with single cars and light loads. The Lyons-St. Just incline has a lower grade of 20% and the upper grade of 6%, the grades being of equal length. To equalize the loads, a counterweight car is used, which runs on the lower (steep) grade, and has its cable attached to the car on the upper (easy) grade. When the descending car reaches the middle of the line, it is freed from the counterweight before descending the steep grade; the ascending car, which now passes onto the easy grade, picks up the counterweight cable and hauls the counterweight up to the top of the steep grade.

Cable inclines are not confined to mountain service and tourist traffic. They have been built in a number of cities to connect high-level and low-level districts. There are three at Lyons and others at Pera (Constantinople), Havre, Treport, etc. There are some also in England. Among the few inclines of considerable length and used for regular railway service may be noted those of Santos, in Brazil, and the Ashley planes of the Philadelphia & Reading R. R. The latter (described in our issue of March 25, 1909) handle trains of about six ordinary coal cars; there are three inclines in series, 3,000 to 5,000 ft. in length, with grades of 5.7%, 9.28% and 14.65%; the total rise is 1,013.75 ft. The Santos line has four consecutive planes of 10% grade, with lengths of 640 to 885 ft., and a total rise of nearly 260 ft. The average train load is 30 tons. As originally built (1860) there was a passing place at the middle of each incline, with a single track below and a three-rail track above. The growth of traffic necessitated additional capacity, and a second track was built, but owing to the numerous tunnels and viaducts the tracks are gantletted and trains can pass only at the middle and ends of the inclines. These improvements were made between 1896 and 1901, and at the same time some of the grades were reduced to about 8%.

As a rule, there is a single track with a passing place at the middle. Sometimes there are two tracks, but gantletted so that the two rails of each line are only a few feet apart; except



Special Rail for Cable Inclines, (the High Head is Engaged by the Jaws of the Emergency Grip Brake).

at the passing places. Above the passing place there may be only three rails, and with this arrangement only a single frog is required. The Territet-Glion line has an ordinary double track, thus avoiding all frogs and switches.

The gage of track is usually 1 meter, though a few lines are of standard gage. A substantial track construction is essential, for while the rails do not have to carry heavy locomotives or cars, they have to sustain the action of the emergency brakes, except where a rack rail is used. For this reason, the tendency is to use heavy rails. The prevention of creeping of the track is another feature of importance with grades exceeding 15 to 20%, but with a less inclination there seems to be little tendency to creep. Many lines have the rails attached to longitudinal timbers laid on cross ties, while in other cases the longitudinals are short timbers fitted between the cross ties. On the Giessbach line, with grades of 24 to 32%, the ends of the ties are connected by longitudinal channels, while the ties also bear against iron bars embedded in masonry. On the Burgenstock line, with grades of 58%, the rails are attached by bolted clamps to ties of steel angles 3½ × 5 ins., having the 3½-in. arm embedded in masonry; to prevent creeping of the rails, the middle of each rail is secured directly to the tie by a bolt through the flange. Furthermore, angle splice bars are so arranged as to butt against the joint tie-plates, and on very steep grades each rail may have one or two short pieces of angle bars, bolted to the web and bearing against tie-plates.

Emergency brakes with jaws gripping the web of the rail are commonly used, so that ordinary splice bars cannot be applied. In some cases, a grooved tie-plate is fitted under the joint, and this may be supplemented by a plate riveted to the flange of the down-grade end of the rail, so as to butt against the joint tie-plate and so prevent creeping. On some lines a special rail of exceptional height is used, having a longitudinal rib on each side at the middle of the web; the upper part of the web serves for braking, while angle splice bars fit against the lower side of the ribs. Another rail has a high and pear-shaped head like an inverted wedge, and the brake jaws engage with the head instead of the web. This type of rail as used on the Stanserhorn incline (and shown by the accompanying cut) is 5 ins. high, with a head 2¼ ins. high; the width of head at its base is but little more than the thickness of the web, being just sufficient to form a shoulder to fit the upper edge of the splice bars. When the grip brake is applied, a slipper brake is pressed upon the rail head to offset any vertical lifting action of the rail due to the pressure of the grips on the sloping sides of the rail head.

The brakes applied to the cars to stop them in case the cable is broken, are of four types: (1) track brakes, gripping the rails; (2) band brakes on drums on the axles; (3) lever or "parachute" brakes; and (4) rack rail brakes. These cannot be used when the profile is irregular and the grades are variable, since the reduced tension of the cable at certain points would cause the brakes to act. Those of the second class cannot be relied upon for very steep grades, as the first action of the brake is to skid the wheel, when the cars would slide by gravity. In those of the third class toggles or cams cause toothed levers to project beyond the car and engage with longitudinal timbers on each side of the track. An example of this type is the brake on the car of the counterweight cable incline for controlling electric cars on a steep grade at Seattle, described in our issue of March 9, 1911. With the fourth type, a rack rail is laid in the middle of the track, and the car has a cog wheel on a shaft which carries also a drum for a brake band. This brake may be under the control of the motorman to check or stop the car, or it may be automatic. These are used on a number of lines, especially those operated on the gravity or water ballast system. Where the cable is operated by engines or motors, the rack brake can be used only in the event of the cable being fractured; if used to check the movement of the car it would cause the cable to become slack and lead to injury. The rack may be of the ladder, bar or rail type. It may be noted that the Mt. Manitou cable incline in Colorado has two fixed cables which extend along the track and pass through grips beneath the car. In case of breakage of the hauling cable, these grips would close upon the fixed cables and hold the car.

A special type of cable incline is that in which the cars are suspended from carriers or trucks running on cables, as in cableways or aerial tramways. Such a line is that of the Wetterhorn (described in our issue of July 22, 1909) in which the grade is about 110%.

For the driving plant of power-operated lines, the cables may be passed around a drum or sheave driven by gearing which is operated either from a steam engine or an electric motor. In a great majority of cases this plant is at the head of the incline, but at Ofen (Hungary) it is placed at the bottom; in this case there is only one car.

*"Cable Railways and Aerial Tramways" (Chemins de Fer Funiculaires, Transports Aerien). By A. Lévy-Lambert.

Progress on the Cape Cod Canal.—Buzzards Bay channel is more than half done and a continuous scow channel has been dredged from Wing's Neck light to the mouth of the Monument River. The new highway bridge and approaches at Bourne will be completed and ready for traffic by the end of the month when the Shore Road bridge will be removed. Steam shovels are engaged in the summit cut between Bourne and Sagamore removing as much dry excavation as possible in advance of dredging. Over two miles of canal westward from the Sandwich entrance is completed and the cut will be extended across the highway at Sagamore by Nov. 1, when a temporary bridge will be installed at that point pending final arrangements for a highway crossing.

The breakwater is completed to its entire length and height with about two-thirds of the total amount of stone in place. About one mile of canal bank has been protected by the placing of riprap to prevent erosion.—"Bulletin of the Boston Society of Civil Engineers" for October.

Aerial Tramway and Cable Inclines for Passenger Traffic in Colorado.

The mountain regions of Colorado and the west offer many opportunities for special railway construction to facilitate access to elevated points of view, but this field has been cultivated only to a small extent, possibly because the tourist traffic has not been developed as yet to such an extent as to make lines of this class a profitable enterprise or investment. We describe below, however, three lines which present features of special engineering interest.

The Sunrise Peak Aerial Tramway.

This is perhaps the only aerial tramway built for passenger service now in operation in this country,* but its promoters saw the possibilities of developing tourist traffic by a line of this sort. In view of this purpose, the cables, bents, towers, and operating machinery were all designed and built with a greater safety factor than is usual in the construction of ordinary lines of this class. It is owned by the Colorado Mines & Aerial Tramway Co., of Silver Plume, Colo., of which Mr. Geo. F. Wilson is Superintendent. The construction was at first let under contract, but it was taken at too low a price so that the contracting company dropped it, and it was finished under the supervision of Mr. C. B. Falley, of Salem, Ill., as engineer and superintendent.

The tramway starts near Silver Plume (the terminus of the "Georgetown Loop" line of the Colorado & Southern Ry.) and ascends the Sunrise Peak of Mt. McClellan. The elevation of Silver Plume is about 9,189 ft. above sea level. The length of the cable tramway (cable measurement) is 7,000 ft. It has a maximum angle of 43° (98%) and a minimum of 18°; the average is 28½° (54%). The total rise is about 3,300 ft.; giving a summit elevation of about 12,500 ft.

The cables are supported by bents and towers built of native pine and Oregon fir, the height of the towers ranging from 18 to 60 ft. The longest span is 485 ft. (horizontal measurement), and the shortest span is 80 ft. The profile is very irregular, and the frequent sharp changes of grade necessitated the construction of supporting towers of such dimensions and spacing that the cables would not be subjected to excessive bending. In that dry climate the life of the wire rope depends upon the treatment it receives, and abrasion and excessive bending are the worst causes of wear. As the vertical angle of bend was the governing factor in the location, it was found necessary to cluster the supporting towers sufficiently close that the bending angle over each support would result in a curve that would not overstrain the wires.

The two stationary track cables are 1½ ins. in diameter, made up of 42 crucible-steel wires and having a tensile strength of 150 tons. They are spaced 8 ft. apart horizontally, and are carried by cast-iron saddles supported by steel brackets from the 12 × 12-in. Oregon fir cap on each tower. A clip of ⅛-in. steel is bolted to the saddle on the cable, to hold the cable in place. The traction or haulage cable is a continuous 1⅛-in. plow-steel cable with six strands of 19 wires each and a hemp core. This has a breaking strength of 56 tons. The factor of safety is 10 for the haulage cable and 16 for the track cable.

The traction cable was made in one length and spliced after being run around the driving sheave at the top and the terminal sheave at the bottom. A plain splice, with the ends of the wire protruding, was found to be more durable than the usual one with the ends tucked in. At the sharpest points of deflection the traction cable is supported by cast-iron sheave wheels in order to avoid excessive bending and to relieve the car frames and track cables of excessive strain, caused by the load farther down the mountain. Guard rails are placed on the towers or bents supporting these sheaves to guide the cars outward far enough to prevent their frames from striking the sheave wheels or supports.

*See Eng. News, Jan. 31, 1895 and July 22, 1909, for descriptions of aerial passenger tramways in Europe.

The track cables are stretched by winches to conform to the angle of incline, the loads they have to sustain, and the changes in temperature. The stress on the track cable does not vary much with differences of incline because it is stretched to a maximum safe tension by the winches at each lower end. At the terminals and tension stations, the track cables are carried down to anchors in the rocks at their upper ends or to tension winches at their lower ends. A steel rail track is used to carry the cars around the terminals or from one track cable section to another.

In order to secure a high safety factor and to apply proper tension to the track cable at an intermediate point a tension station is located at the middle of the line, at which the track cables end. Those from the top pass through this structure to the tension winches just below the station. Another set of track cables is anchored in the rock just above the station through which they are carried to supports at the lower end, where they are secured to the connecting steel track. At the lower terminal they deflect to the tension winches and a steel track again carries the cars around to the other track cable. The traction terminal is moved backward or forward

A Passenger Car on the Sunrise Peak Aerial Tramway; Silver Plume, Colo.

by winches to adjust the tension of the traction cable to changes in temperature and to that of the track cables. Short sections of steel track are provided to fill in the space caused by such movements. The adjustment can be made in a very few minutes.

The driving machinery is at the upper terminal and is operated by electricity. The driving sheave is 8 ft. in diameter, and is of heavy construction, weighing about 4,800 lbs. Around its edge are clamps, adjusted by strong springs, and forced upward at their inner ends by a horizontal cam so that their outer ends, or fingers, clamp the cable the moment it comes into contact with the sheave, and prevent it from slipping. It runs at about 13 r. p. m. The sheave is keyed to a 7½-in. vertical steel shaft driven by two 35-HP. induction motors, through a set of bevel gearing at the base of the shaft and one set of spur gearing, belt-connected to the motors. The electricity is developed by a hydro-electric plant, and carried at a voltage of 10,500 to the summit, where it is transformed to 440 volts.

Brakes are provided for both service and emergency stops. When the downbound load greatly exceeds the upbound, both brakes are often necessary. The operator starts the line by means of a friction clutch on the main drive or belt pulley. The stopping of the cars is controlled by means of levers which connect with brake bands on the sheaves. The round trip is made in about 46 minutes. The line is equipped with a complete signal system. Three watch towers are located at convenient points on the line, and at each of these is a watchman having telephone and signal bell connection with the upper and lower terminals. There is provision also for signaling the operator and the watchmen from any part of the line by telephone or signal bell. Electric oil switches are located at the top so that the power may be shut off from either point instantly. This is especially necessary during the severe electrical storms common to this part of the Rocky Mountains.

There are 26 cars on the line. They are of pressed steel, weighing about [illegible] lbs. each, and are designed to carry four passengers. The load capacity is 2,000 lbs. Each car is fastened permanently to the traction cable by a heavy cast-iron pivot and steel U-bolts. It is suspended from a two-wheel truck which rides on the track cable, the suspension being by means of a long bail which is reinforced by truss pieces so as to be very rigid. The truck wheels are constructed to fit the track cable closely and are provided with pressed steel flanges 4 ins. long, inclined outward so as to pass over the track cable saddles and other supports without possibility of derailment. The movement of the cars is said to be quite steady. The accompanying cut shows one of the cars in service. From June 16 to July 20, 1911, the total number of paying passengers carried was 2,682.

The Mount Morrison Cable Incline.

This is one of the few mountain climbing cable inclines in this country, although in the mountain districts of Europe numerous such lines have been built. Mount Morrison is about 16 miles southwest from Denver, and its summit is about 8,000 ft. above sea level, or 2,830 ft. above Denver. The incline has a track gage of 5 ft. 4 ins. to allow of using wide cars, which carry 100 passengers. There are three rails, so as to avoid the use of frogs at the half-way passing places.

The cables are two in number, 1¼ ins. in diameter; each having six strands of 19 wires of specially drawn crucible steel. At first only one cable was attached, the other being stored for future use. The hoisting plant consists of a pair of 14 × 20-in. reversing hoisting engines. These are connected by means of a train of powerful gears to a 10-in. shaft on which are keyed six sheaves 10 ft. diameter, each sheave being grooved for two 1¼-in. ropes. These sheaves are the drivers, and there are five sheaves 8 ft. diameter on a separate parallel shaft for carrying the rope across from one 10-ft. sheave to the other. There are two cars, one being at the top, while the other is at the bottom, each being attached to opposite ends of the two 1¼-in ropes. In operation, one of the cars is lowered while the other is raised, the cars passing in the middle of an ordinary passing track; the engine is then reversed and the cars are moved in the opposite direction, carrying a load at each time.

The brakes supplied with the outfit, are two powerful post brakes attached to the shaft on which are keyed the 10-ft. driving sheaves. These are operated by the engineman. No safety appliances were supplied for the engine or cars outside of the post brakes above mentioned. The cables and machinery equipment were supplied by the Hendrie & Bolthoff Mfg. & Supply Co., and the Vulcan Iron Works Co., of Denver. The line was projected and built by Mr. John Brisben Walker, of the Colorado Power, Water, Railway & Resort Co., Denver.

Mt. Manitou Incline.

Another cable incline is at Manitou, Colo., ascending Mt. Manitou, whose summit is 9,500 ft. above sea level. The line is 1¼ miles in length with its upper terminal about 2,500 ft. above the lower one. It is operated by two cars in the usual way, the trip in each direction being made in about 16 minutes. The operating cable is a 114-wire cable, with a test load of 90,000 lbs., and an actual load not exceeding 9,000 lbs. (factor of safety, 10). An interesting feature is that there are two fixed safety cables, which pass through automatic grips and clutches under the cars, and in case of failure of the hauling cable these clutches would grip the safety cables. The hoisting machinery is at the upper terminal, and is operated by an electric motor of 200 HP. Each car seats 30 persons, and carries a conductor who has signal communication with the operator.

Two Producer-Gas Tug Boats have been in regular service on the Lehigh canal between New Hope and Bristol, Pa., (26 miles) since May 30, 1911, according to a descriptive article in "Power," Oct. 17, 1911. The tugs are 41½ ft. long with 10½ ft. beam. Each can haul four or five 100-ton barges at 4 mi. per hr.

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Mountain Railways for Tourist Traffic.

The construction of railways for tourist traffic has been developed on a large scale in Europe, but has had only a small beginning as yet in this country, although there is a field for and a probability of further development by promoters and engineers, by reason of the steady increase in traffic of this kind in the United States.

The ascending of peaks and elevated points commanding extensive views is always a great attraction for visitors to mountainous country, and with the enormous development of pleasure travel and tourist traffic in Europe, much has been done to accommodate this desire (and earn profits therefrom) by the construction of railway lines to such points. Most of these are of special types with very heavy grades (as high as 50 to 110% in some cases) and the majority are rack railways or cable inclines. An exceptional type is the inclined cableway, and a line of this class for the ascent of the Wetterhorn has been described in our columns. These railways present much of interest in regard to their construction and their methods of operation.

In this country comparatively little has been done in this direction, partly, perhaps, because the tourist traffic in our mountain region has not developed to such an extent as that of Europe. There are two rack railways in the United States (Mt. Washington and Pike's Peak) and a steep grade adhesion line (Gray's Peak); also a few cable inclines in the East and the West. The Gray's Peak line we have described recently, and elsewhere in this issue are described three other lines in Colorado. Two of these are cable inclines (one operated by electric and one by steam power.) The other is specially notable as being an adaptation of the familiar aerial tramway to passenger and tourist traffic.

Two requisites for such lines are relatively low cost of construction and operation and a high degree of safety in operation. The latter feature, unfortunately, seems to be given much less consideration in this country than abroad, and cheapness, with a minimum of engineering advice in construction, is too often the main consideration, although, of course, this is not always the case. In Europe, however, the lines require governmental sanction, and in most cases they have to comply with strict rules and requirements as to construction, equipment and operation. Under these conditions, engineers of skill and prominence are attracted to this line of work, with the result of rapid developments in special construction, brake equipment, safety appliances, and many other matters of detail.

An Irrational Basis of Water Rates at Baltimore.

Among the many irrational systems of charging for water, perhaps none is more absurd and unjust than the one which bases rates on the frontage of the building supplied. This plan is generally accompanied by extra charges for special water fixtures, which, in some instances, tends to lessen the injustice of the plan, but as a rule still leaves it highly objectionable.

The frontage charge becomes all the more irrational and unjust when the water rates of a community are used to help keep down the general tax rate, as has recently been proposed at Baltimore, Md. In that city, it appears, a 30% increase in frontage charges was proposed in order to avoid an increase in the general tax levy. Some warrant for an increase appears to exist, in view of an alleged deficit in the water department last year. Of course the water-works of every city should be self-supporting, but the water charges should be based on a rational system which takes cost of service and benefits received into account and not on such an arbitrary unit as the frontage of the buildings supplied.

Whether the tax-payers of Baltimore contribute anything toward the water-works charges incurred for fire protection and other municipal purposes, we cannot say, but, if not, the proper thing to do would be to make a just apportionment of the cost of water service in accordance with the benefits accruing to private water consumers and to the general public, respectively.

To make the Baltimore plan appear still more irrational, there has been brought into some of the local newspaper discussion a comparison of the Baltimore water rates with those charged in other cities, which, of course, has nothing to do with the justice or injustice of the Baltimore rates.

We commend to the Baltimore city authorities the two excellent studies of water charges presented before the annual convention of the American Water Works Association at Rochester, last June; one dealing with charges of water for fire protection, and the other dealing more particularly with a basis of meter charges for water-supply for domestic and commercial purposes (see Eng. News, June 15 and July 20, 1911, respectively).

The Public Land Surveys.

We published on p. 446 of our issue of Oct. 12 a letter making criticisms of the work done on some of the public land surveys. While disclaiming knowledge of the particular case referred to in the letter, we believe engineers generally will agree that the change from the contract system of surveying the public lands to the direct employment system is a most salutary reform and one which reflects great credit on the Washington authorities who brought about the change. The general introduction of monuments is also a change which will be of the greatest value and will save an enormous amount of litigation.

With surveyors paid by the day and not by the job the incentive to rush the work regardless of accuracy, and to "fudge" the field notes is taken away. There is no necessity for the careful inspection and extensive rerunning of lines which had to be done when the work was let to contractors. Examinations of the work are made by the Supervisor of each district, who is in the field visiting the different working parties; and experience shows, we are informed, that the quality of the work now being done is far above that common under the contract method, while the average cost per township surveyed has also been reduced.

Another Patent on a Feature of Common Practice in Engineering Construction.

A few months ago we noted in this column the issue by the U. S. Patent Office of a patent for mixing concrete wet. A patent which matches this has recently been granted for a dam made "of loose small rocks of various sizes arranged in the form of a filter, so that the finest grade is situated toward the water and increases in coarseness toward the outside." The single claim of the patent sets forth this grading of the materials in the dam as the chief feature of the invention.

Inasmuch as this principle of dam construction has long been recognized and made use of by engineers, it is passing strange that the Patent Office should allow a patent to issue upon it. Curiously enough, the patent is issued to a German inventor, Willy Todt, of Düsseldorf. It is a safe guess that the inventor has not and will not be successful in securing a patent on his alleged invention in his own country.

What Do the Cities Get for Their Heavy Contributions for State Highway Improvement?

What do the cities get in return for their heavy contributions to the cost of the state highway construction now being carried out on a large scale in many parts of the country? The question is suggested by portions of a committee report made in behalf of the city of Boston by the United Improvement Association, which report appears to have led the Association to request Governor Foss to appoint a resident of Boston to fill a vacancy on the Massachusetts State Highway Commission. Referring, of course, to conditions in Massachusetts the committee said:

> In 1893, when the highway act was passed, the professed object was the assistance of smaller towns in building and maintaining suitable roads, the state paying 75% of the cost of construction. Under this act the highway commission has constructed 785 miles at a cost of $6,300,000. Of this amount Boston has paid $2,270,000, or 34%.
>
> The most prosperous cities and towns have had their roads constructed and maintained. It is evident that all attempts to carry out the professed object of assisting the poor towns has been abandoned. In fact, some of the wealthiest towns, such as Beverly, Milton and Lexington, received their roads within three years after the passage of the act.
>
> Over half the state roads have been built for communities well able to take care of their own roads without the 34% that Boston has been obliged to pay. They would not tolerate many of our city streets.
>
> What has Boston received for its $2,270,000? One piece of road 1.40 miles in length, which actually cost the city $125,000. It has paid for one-third of the state roads in the state and received 1-500th.

Our own impression is that much more has been done for the small "towns" than the committee gives credit for, but there is no disputing the fact that the cities pay a large percentage of the state's contribution for good roads but get only a small percentage of the resulting road improvement. What else do the cities get in return?

No one can say with any degree of precision just what does come to the cities for the money they contribute, directly and indirectly, to the improvement of country roads. They are benefited somewhat, no doubt, by the lessened cost of transportation charges on some of their food and other supplies, though it would be hard to prove this as regards most commodities, since their market price is governed by other things than the character of rural highways. The cities are also somewhat benefited by the fact that good country roads bring farmers and villagers to the city often, and perhaps with fatter pocketbooks than is the case where roads are poor, but all this is more or less vague generalization.

Broadly, city dwellers are benefited by whatever conduces to the prosperity of the rural districts, but if the cities themselves contribute the main or a large part of the cost of producing this rural prosperity the question then becomes one of net return on the city's investment in good roads for the country.

Since the good roads movement began, in the nineties of the last century, first the bicycle and next the automobile, and all the time the builders and sellers of road machinery and supplies,

have been the most powerful promoters of good roads. At the outset these three interests were chiefly confined to cities. Later large numbers of bicycles were owned in the country, just as automobiles of lesser power and value are now becoming common in country villages and among prosperous farmers, but always these interests have been and probably will continue to be city rather than country interests.

Granted that the manufacturers and users of automobiles, of bicycles if they still cut a figure, and those commercially interested in road machinery and supplies are of the city rather than of the country and are the chief or most direct and specific beneficiaries, among city taxpayers, of state highway improvements, what percentage of the good roads taxes contributed by cities do these three groups pay?

We raise the foregoing questions to direct further attention to some phases of the present enormous expenditures for state highway improvements (see editorial note on "Some Good Roads Problems and Fallacies," Eng. News, Sept. 21, 1911), which seem to demand more careful thought than they have yet been given.

So far as specific benefit to city dwellers is concerned, using city in a somewhat inclusive sense, the chief direct benefit from state highway expenditures seems to come to the automobile owner, and he, also, is in large measure responsible for the recent heavy increased first cost and maintenance charges of improved roads. Ought not the present movement to put more of the cost of road improvement on the automobilist be accelerated? Certainly the farmer and the house owner in our small villages and towns, if indeed the general taxpayer in our cities, cannot reasonably be expected to bear increasingly heavy interest and sinking fund charges for immense state highway bond issues, even if the redemption of the bonds is distributed over a period five to perhaps ten times longer than the life of the roads. At the least, the taxpayers of city and country alike may reasonably ask to be shown where the expense and where the benefit to each really falls, instead of being content, as hitherto, with glittering generalities.

The New York Water-Supply Situation Relieved by the October Rainfall.

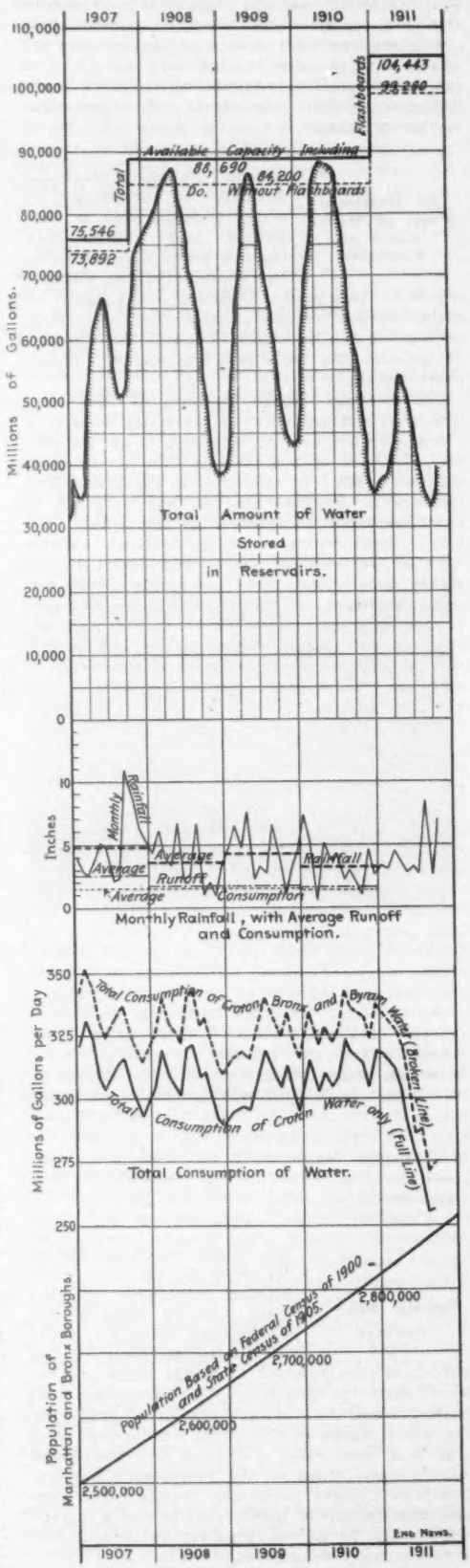
In our issue of May 18 last, we reviewed in this column the grave danger of a water famine in New York City as a result of the long-continued deficiency of rainfall in the Croton watershed from which New York City's present supply is chiefly drawn. We urged at that time that prompt measures be taken to supplement the Croton supply by an emergency supply from the Ten Mile River, a stream lying just north of the Croton watershed.

Following the publication of this article, surveys, plans and estimates were made by the city's Department of Water Supply, Gas and Electricity, under direction of Mr. I. M. De Varona, Chief Engineer, for the installation of an emergency supply from the Ten Mile River. While these surveys were in progress, the situation of the city with respect to the water resources grew more and more serious.

May and June, which are commonly months when a goodly amount of rain may be expected in this latitude, proved exceptionally dry. The rainfall of July was largely dissipated by the evaporation due to the excessive heat of the month.

Early in August, therefore, the department, through its Commissioner, Mr. Henry S. Thompson, presented to the Board of Estimate the completed plans for the emergency supply from Ten Mile River, and asked for authorization for the issue of the city's corporate stock to the amount of $1,200,000 for the installation of the supply.

The plans, as outlined, were identical with those proposed in this journal in May last in all important details, except that it was planned to draw 100 million gallons daily from the river, instead of 50 million, as proposed by us, and to operate the plant during only half the year dur-



Five Years' Record, to Oct. 21, 1911, of Rainfall, Run-off, and Water Storage, on the Croton Watershed and Water Consumption in New York City.

ing the months of maximum flow in the river. In this way it was believed that risk of interference with the work by litigation started by power users in Connecticut would be avoided. As stated in the report:

The main question that will arise is the possible claim for damages, from land owners in Connecticut having riparian rights in the Housatonic River, of which the Ten Mile River is a tributary. Under the proposed plan, however, the supply will be taken during the w[illegible] and spring months, when the flow of the [illegible] is above the average, so that 100 million g[illegible] daily can be extracted with little or no da[illegible] to the power plants on the Housatonic; and [illegible]thermore. The City of New York will not ne[illegible] the supply for more than two or three years[illegible] wing to which facts we hope that the court[illegible] ll not issue a permanent injunction against th[illegible] City when the needs of the latter are clearly s[illegible] wn.

The plant proposed was to [illegible]nsist of steam-pumping machinery of 100 mi[illegible]n gallons daily capacity, taking water from a [illegible]l formed by a low dam across the Ten Mil[illegible] River. A 5-ft. steel pipe line was to extend f[illegible] this pumping station along the railway some [illegible]ine miles to a point south of the divide be[illegible]en the Croton and the Ten Mile watersheds. The estimated cost of the whole scheme, inc[illegible]ding land damages and 20% for contingencies was $1,200,000. This amount was largely in e[illegible]ss of our own estimate, because of the fact that the plant we had suggested was of only half the capacity.

The estimated time required for construction, four months, agreed with our own estimate. It was advised that the authorization for the work be made and everything be ready for undertaking its prosecution by Nov. 1 if the rainfall and water-storage connections during the intervening time made it advisable to proceed.

The Board of Estimate approved the issue of corporate stock for the purpose proposed; and the way was made clear for letting contracts. Had the fall of 1911 been characterized by such drought as has been recorded annually for several years past, contracts for the proposed works would be now under advertisement.

Most fortunately for New York City, the month of August brought a heavy rainfall, over 8 ins., to the Croton watershed. The immediate effect on the reservoirs was not great, for the surface of the ground was dry and the ground water level was phenomenally low as a result of the deficient rainfall of the previous twelve months. It is worth noting that during the twelve months ending Aug. 1, 1911, there was a smaller rain-fall than in any consecutive twelve months since the Croton records began in 1868.

A large part of the August rains, therefore, went to moisten parched soil and fill underground reservoirs; but its effect on the permanent flow of the streams was none the less important.

September was another month of deficient rainfall, only about 2½ ins. being recorded. Yet this, with the ground wet from the August rains, maintained a fair flow in the Croton streams and left the surface in good condition to shed the water from following rains. The first week in October a rainfall of 2.37 ins. was recorded, which so stimulated the flow in the streams that a slight gain occurred in the depleted reservoirs, the net result for the week being 533 million gals. added to the amount in storage.

With this favorable showing, and with the experience of previous years as to normal flow in the river, the Department of Water Supply decided to abandon for the present the Ten Mile River project. While the amount of water stored in the Croton reservoirs on Sept. 30, 1911, was about 25,000 million gallons less than was on hand a year earlier, the records of average flow in the Croton River during October for many years indicated that enough run-off might be counted on so that the city might have at least 20,000 million gallons still remaining in the reservoirs by Jan. 1 next.

The assumption on which the recommendation was originally made to take up the Ten Mile River project was that at least that much water must be in storage on Jan. 1 to safeguard the city from water famine during 1912. Mr. de Varona, Chief Engineer of the department, therefore advised that nothing further be done regarding the Ten Mile River project until next spring, when the results of the fall and winter rains are known. In the event of serious shortage of rainfall during the winter, it will still be possible to undertake the work upon the Ten Mile River project next April or May, and have it completed in time to be of use for the city during the fall of 1912.

Since the department's recommendation of Oct. 9, further rain has fallen in the Croton watershed. Rain fell there almost continuously during the week ending Oct. 21, a total of 3.71 ins. being recorded. On Oct. 22 nearly an inch additional fell, making the total rainfall in the Croton watershed for the month of October up to the present time 6.95 ins.

These rains, coming at a season of the year when evaporation is low and on ground already wet by the rains during the early part of the month, have raised the streams of the Croton watershed to a height not reached for many months. Instead of further depleting the Croton reservoirs during the week ending Oct. 21, the amount in storage was actually increased by 3.89 million gallons.

We published in our issue of May 18, 1911, a diagram recording graphically the storage, rainfall, run-off and consumption of Croton water by New York City. We repeat this same diagram herewith for the five years from 1907 to 1911, inclusive, adding the records for the later months of the current year.

Besides the interesting figures shown on this diagram for storage, rainfall and run-off during the current year, the most notable feature is the reduction of water consumption which has been effected through the inauguration of a systematic house-to-house inspection. The reduction in consumption which has been brought about through this means has been a most important factor in helping to tide the city over the period of deficient supply.

It is evident that until the additional supply from the Catskills is made available, New York must by all means continue these measures for restricting waste in order to be in any degree safe from water famine. The diagram which we published May 18 last showed that the water consumption of New York has not increased since 1906, notwithstanding the great increase in population.

It probably will not be possible to hold the city down permanently to the present scale of consumption. With the installation of the new Catskill supply, it is, we regret to say, only too likely that waste will go on again unrestricted. One could wish, however, that the lesson of these past few years of enforced economy might be learned. Wasted water benefits no one, and lays upon the already overburdened taxpayer an additional load.

Again and again in these columns it has been pointed out that it pays to prevent water waste. In New York City, we are informed, the amount of water saved during the present year since Jan. 1 through the prevention of waste by systematic inspection and otherwise amounts to 7,595 million gallons. If this water had been sold to consumers at meter rates, it would have netted the city a revenue of a million dollars, in round numbers. The value of this water saved and stored to safeguard the city from danger of a water famine is, we are sure, many times a million dollars.

We could wish, however, that New York might be wise enough to copy the experience of other cities and improve upon its house-to-house inspection system by the general adoption of water meters. The water meter is the only kind of inspector which works 24 hours a day for 365 days in the year, and which cannot be bribed to neglect its duty by winking at leaks or waste of water.

It is still within the possibilities, of course, that deficient rainfall during November and December and during the winter months may put New York in danger of water famine. All past experience, however, indicates that a goodly amount of rainfall and run-off may be expected during the coming six months; and with the ground water level restored by the rains of August and October, there is good ground for hoping that the Croton reservoirs may be filled before another summer to a level which will make New York really safe against the danger of water famine until water from the Catskills may be available to supplement the Croton supply.

Determining the Capacity of Reservoir Spillways.

The serious floods on the Black River in Wisconsin, due to the overtopping of earth dikes, described in detail by Prof. W. D. Pence in our last week's issue, should serve to call the general attention of the engineering profession to the important matter of spillway proportions.

It is often said that it is easy to be wise after the event, and it is, of course, easy to say, after the floods which swept around the Black River dams, that their spillways were not made capacious enough originally. Reference to the river data given near the close of Prof. Pence's article, however, shows that there was on record at the time the dams were built, data regarding recent floods in the Black River which should have warned the designing engineer to be much more generous in his provision for flood flow over the spillways.

The spillway at the Dells dam, the upper one which failed, was 260 ft. long and was designed for a maximum depth of 6 ft. of water. Emergency work on the earth dikes abutting the spillway apparently increased the depth to about 8 ft. before the dike was overtopped. Assuming the 6-ft. depth as the normal maximum flow, however, rough computation on the basis of the table given in Fanning's "Water Supply Engineering" indicates that the Dells dam spillway could be relied upon for a flow of about 13,000 cu. ft. per sec. The Hatfield spillway, on the same basis, may have been good for something over 30,000 cu. ft. per sec.

As to what the actual maximum flood volume was in the Black River during the recent flood, computations are not yet at hand. It is entirely clear, however, from the rapid rise of water in the reservoirs that the flood volume was very greatly in excess of the spillway capacity.

Prof. Pence quotes from Smith's "Water Powers in Wisconsin" the statement that a flood flow in the Black River of 23,000 cu. ft. per sec. was recorded at Neillsville, Wis., in June, 1905, Neillsville being several miles upstream from the Dells. The area of the Black River watershed above Neillsville is 729 sq. mi., so that the flood flow of June, 1905, at this point was about 31½ cu. ft. per sec. per sq. mi. of tributary watershed.

At the Dells the tributary watershed has an area of about 950 sq. mi., and if we allow 30 cu. ft. per sec. per sq. mi. for rate of flood flow, this would give a volume of 28,500 cu. ft. per sec. as the flow which might have been expected over the Dells dam whenever the flood conditions existing in June, 1905, should be reproduced. By comparing this with the figure for capacity quoted above, it will be seen that the Dells dam ought to have had a spillway of more than double the capacity in order to safely carry such a flood as was on record only four years before the dam was built.

At Hatfield the tributary watershed has an area of about 1,350 sq. mi., and assuming again 30 cu. ft. per sec. per sq. mi. as a maximum rate of flood flow, there would be a flood volume of over 40,000 cu. ft. per sec. to be taken care of. While the Hatfield dam spillway was considerably more liberal in its proportions than that at the Dells dam, it could not safely carry more than three-fourths of this amount.

Further than this, in view of the known character of the Black River, its steep slope and the small pond capacity on its watershed, it appears certain that a considerably larger rate of flood flow than 30 ft. per sec. per sq. mi. of watershed ought to have been assumed in proportioning the spillways. As to what would have been a safe allowance, we shall by no means attempt to say. We do wish, however, to point out the meager data in engineering literature with reference to this matter. One may read a dozen descriptions of dams and not find in a single one a record of its spillway proportions in terms of flood flow cubic feet per second per square mile of tributary watershed. It is just this sort of data with respect to design which make a description of an engineering structure useful to the profession.

Perhaps there may be recent monographs on this subject which have escaped our attention; but the subject is one which ought to be well investigated and the results put on record. If some engineering student ambitious to prepare a really useful thesis will undertake an exhaustive search through technical literature for all available records of spillway proportions, and will present the results in usable form, he will bestow a real boon on the profession.

The question of spillway proportions is coming up continually wherever dams are being designed and built, especially those for water-power development. Dams built in connection with municipal water-supply and irrigation are commonly located on comparatively small streams of limited drainage area, so that the matter of spillway provision is more easily taken care of.

It is indeed a difficult question to determine just how large a spillway capacity it is reasonable to provide for on a water-power dam. There are cases, of course, where the property and lives at risk and the funds available for construction will warrant the engineer in going to unlimited expense in provision for flood flow. These cases, however, are the exception rather than the rule. In the case of most water-power development work, it is true, we believe, that the dam must be built with an understanding that more or less flood damage may result at intervals of 20 or 40 or 60 years, when extraordinary flood volumes come down the stream.

It may be of interest to discuss what measures the engineer should take to solve this difficulty. Many of our readers will remember that classic story in the annals of engineering concerning the great emergency gate built by the late James B. Francis at Lowell, Mass., to protect the city from overflow from the power canal in case of an extraordinary flood. It has been often told how the gate was for many years called "Francis' folly," and how it stood for many years unused and, to the lay public a striking object lesson, apparently, of the excessive caution of a "theoretical" engineer.

The day came, however, when the emergency flood for which the great gate had been planned came down the river. The gate was lowered into place and the people of the city learned the wisdom which lay beneath the design of "Francis' folly."

It is well to frankly recognize, however, that under present-day conditions there are comparatively few cases where the engineer in charge of the work will be able to make such liberal provision against damage likely to occur only under extraordinary conditions.

The question put up to the designer of a dam is how can he provide for extraordinary floods without undue expense and with the minimum of damage when the emergency does come. There are a number of solutions for this problem, and it should be said at once that the solution which is best for one situation may not necessarily be best for another. Movable dams of one type or another have often been proposed and have been used to some extent for water-power purposes. Where excessive flood flow is a normal annual event, the movable dam is perhaps as good a solution as can be found. In the Ohio River, for instance, it would be impossible to install fixed dams at most points in the valley without causing enormous damage by flood overflow at times of highest water. On most of the smaller streams on which water-power is developed, however, the movable dam is too expensive to build and maintain, and it wastes too much water by leakage during low stages of the river. The main problem with the majority of water-power plants is to save every drop of water for use during dry seasons; and no form of spillway machinery will be acceptable which causes waste by leakage.

An excellent plan for increasing the capacity of a spillway is to incline it across the stream, instead of running it across at right angles; or it may be built in V-shape or on a semicircle. There are cases where a dam is built at the site of a natural fall where spillways of such a form may be more economical to build than a straight spillway. But where the spillway structure is of considerable height, or where the foundation for it requires to be car-

ried deep down in the rock, such increases in spillway length mean a heavy addition to the cost.

The siphon spillway is a comparatively recent invention, which has been used on some structures on the New York Barge Canal, as described in this journal a few months ago. A siphon spillway built in Germany was described in our issue of Aug. 3, 1905. The principle of the siphon spillway is simply that of the ordinary siphon, the tube built through the crest of the dam being carried down in the masonry on the lower side so that the draft of the water falling through the tube is available to increase the velocity in the neck of the siphon. Theoretically, for a dam not over 30 ft. high, a siphon spillway should have the same capacity as a horizontal tube of the same cross section extending through the dam at its base. Practically, the necessary curvature of the siphon, with the friction of entrance, would considerably reduce its discharging capacity. One trouble with the siphon spillway, or with any such means of emergency drainage for a dam, is that in times of flood large amounts of driftwood are apt to be brought down and are carried by the current toward any opening, and being held there by the suction tend to choke the flow.

For high dams, say those of more than 40 or 50 ft., emergency tunnels of good size through the body of the dam, or through the adjacent rock, can materially supplement the flow over the spillway. It is almost needless to say that such tunnels need to be very carefully designed in all details, in order not to cause leakage or endanger the structure, and in order to be secure against clogging that may either choke the out-flow or prevent the closing of the tunnel after the need for it has passed.

One point which deserves emphasis in connection with the design of spillways is that their clogging by drift brought down by floods may materially reduce their capacity. The photograph of the Hatfield dam spillway, on page 484 of our last issue, showed a large amount of driftwood lodged behind the flashboard standards on the spillway. It has been often pointed out how dangerous such flashboards may become unless they are so designed that the flood will sweep them clear and permit free passage of water over the crest. One cause of the flood which wrecked Johnstown was the obstruction of the spillway of an earth dam first by a fishguard grating and then by floating drift.

What appears to be an excellent method of increasing spillway capacity was that noted in our description of the great dam across the Mississippi at Keokuk, Ia., now under construction, which appeared in our issue of Sept. 28, 1911. A bridge is carried along the crest of the dam and large Stoney gates permit the raising or lowering of the spillway crest between each two piers of the bridge, a total variation of 11 ft. in the height of the crest being thus made possible. With this construction, there are no projecting parts to catch running driftwood. Wherever such a construction can be afforded, it furnishes an admirable solution of the problem of provision for flood flow, while at the same time enabling the water to be held at maximum height during the low-water season.

There is one plan of providing for extraordinary floods which we have never seen proposed, but which really seems to deserve serious consideration for dams of small height, flanked by a broad valley on each side, where it is necessary that the flood flow be confined to the channel to avoid extensive property damage. If a hollow reinforced-concrete dam were built at such a location, it could be designed with a spillway of sufficient capacity to take the normal rate of flood flow. Then, to pass an extraordinary flood, such as may come perhaps only once in a quarter or half a century, several sections of the dam could be blown out with dynamite, leaving an open passage for the water through the section thus cleared. This may seem like a heroic remedy, but it is probable that it would be far cheaper to rebuild a few sections of the dam after such rare floods than to provide some costly emergency apparatus, which would be unused for so long an interval that it might prove inoperative at the time when it was needed.

LETTERS TO THE EDITOR.

Movement of Ice on a Reservoir Surface by Wind.

Sir: Mr. Freeman's "Thoughts Suggested by the Austin Dam Failures" in the current issue of Engineering News calls to mind a phenomenon I once witnessed which demonstrates the tremendous force which may be exerted by wind blowing across a sheet of water covered with ice.

I had been ice boating on a fair-sized lake in Massachusetts one winter morning. The weather was mild and a rain set in, forcing us to abandon our sport. As we came ashore we had hard work getting the ice boat across a crack which had widened, during the few hours we had been out, from less than an inch to a couple of feet.

The rain and a moderate wind continued till late in the afternoon, and the surface of the ice was made very wet and slippery. On my way to the train I passed around the edge of the lake a mile or more from the crack I had noticed opening up during the morning, and I saw why the crack had widened. The ice, a foot or more thick, had been forced several feet up a rather steep, rocky bank, and the stones and boulders plowed up by it had rolled back down the sloping ice.

It was evident that the moderate wind had gotten sufficient grip on the slippery sheet of ice to move it.

H. F. Tucker.

60 Greenough St., Brookline, Mass., Oct. 20, 1911.

The Non-Graduate Engineer in the Field.

Sir: I have read with interest the letter of Mr. Lavis in your issue of Oct. 12 in defense of the "non-graduate engineer." Many of your readers know Mr. Lavis and I am sure endorse his expressed opinions.

The college graduate engineer is entitled to the same show as any one else, whether he has worked his way up from the ranks or not. He has got to "produce the goods" and get out and "hustle" or get left.

I am not an engineer, but I have been in the active construction field since 1886 in all capacities, under a good many chief engineers, their assistants, general managers, and presidents, not one of whom, to my knowledge, has ever had a collegiate training, but they have all "produced the goods" and are still successfully "producing."

Regarding the remuneration: The laws of supply and demand seem to regulate that.

Many men I know of do not take positions simply for the "lucre" in it, but for the interest the work awakens in them.

Personally I have gained more valuable experience in the great school of "out doors" on general construction work than in the class rooms of a famous old European university, and I am still learning.

"G. H."

Tunnelton, W. Va., Oct. 16, 1911.

More Concerning Hollow Dams.

Sir: I have read with interest your editorial comment on my letter published in your issue of Oct. 12, 1911.

Permit me to state that there is nothing about the construction of a dam with a sloping up-stream face to prevent the construction of a sloping down-stream face or of a down-stream apron of the proper curve or slope to properly deflect the water overflowing same. As a matter of fact it is easier in the case of a hollow dam than in the case of the average solid dam to make the down-stream face of mathematically the proper curve so that there will be no suction on account of the hollow, vacuum-like, space underneath the sheet of water which will occur if the down-stream face is too steep.

In the dam at Austin, Tex. (for instance), the down-stream face was curved with an idea of having the overtopping water run down same, but on account of the force of the water under a flood head, the water after leaving the crest of the dam would shoot way over the whole structure and land with an eroding vertical drop on the down-stream toe of the dam. This eroding force in flood time was probably one of the main contributing causes for the ultimate failure of the dam under a flood. In other words, even with a vertical up-stream face in a solid masonry gravity dam as ordinarily built, the down-stream profile will not be the curve which will be followed by the water in flood time. With a supported deck, however, it will be an easy matter to build a down-stream apron with the proper curve and support same with foundation walls in the same manner as for the up-stream inclined deck.

In the design of a dam with an inclined deck properly supported underneath, if built of concrete, it is not necessary that any absolute dependence should be placed on reinforcing bars of steel. The deck, in other words, can be made a system of arches with very little or no reinforcement in them, and of such a design that if the reinforcement were to rust away there would still be strength enough to properly take care of the load. Of course it will be much easier to properly design such a structure if at least partial dependence is placed on the reinforcement, and to get the full benefit of the economies of this type of construction over the solid masonry dam, such dependence is requisite. As above suggested, however, it is quite possible to economically design a dam with a supported up-stream deck and a supported down-stream apron entirely of masonry and properly designed for stresses inside of the usual limits and placing no dependence whatever upon reinforcing steel.

Wm. M. Torrance.

39 Cortlandt St., New York, Oct. 14, 1911.

The Development of Ash-Conveyor Systems.

Sir: In your issue of Sept. 28 I note a discussion relative to power consumption and maintenance of the suction system as compared with the pivoted-bucket system, for handling ashes. Mr. Hudson says in his letter:

> For handling ashes, about the only other form of conveyor suited to the usual conditions in large power plants is the pivoted-bucket carrier.

I wish to champion the cause of the simple machine which was not mentioned, but which is used exclusively in all of the Philadelphia traction-company power houses and in most of the large New York stations. In fact, is undoubtedly the most common system in use for handling ashes in boiler houses, ores at blast furnaces, and crushed stone, sand, etc., for concrete mixing plants. This is the car-and-skip-bucket system. While power consumption and cost of repairs have been mentioned, there are also other important factors which should be considered. These are (1) maintenance and repairs, (2) first cost, (3) operation labor, (4) capacity, (5) flexibility in application, (6) immunity to breakdown or derangement, (7) power consumption. The car-and-skip system meets these seven requirements more nearly than either the suction or pivoted-bucket system. This system includes a push or electric car to collect the ashes from hoppers below grates and one or more skip buckets to hoist to overhead bunkers.

Under the item of "first cost," we have the industrial track, electric car, skip bucket and electric freight-elevator hoist. These are all low-priced items.

Under "maintenance," we have the repairs to the ash car, skip bucket and freight elevator hoist. This is very low because the electric hoist is located in a position absolutely free from dust so it is not subject to more wear than any standard freight elevator. The ash car and skip bucket are very little affected and are cheap to replace when worn out.

Under "labor cost," is really involved capacity, because the real question is tons of ashes per hour per man. One man with a 1-ton motor car and trailer on a 300-ft. haul could handle 40 to 50 tons of ashes per hour. Coal-skip systems handle up to 150 tons per hour, and ore-skip systems much more.

"Flexibility" involves ability of the system to meet various arrangements. The car can be run in any horizontal direction and the skip at any angle up to vertical. These features enable the system to meet almost any conditions.

"Immunity to breakdown" involves the dependability of a trolley car and a freight elevator. The reliability of these devices are well known.

"Power consumption." The coefficient of friction of the trolley car is not over 3% and in a balanced skip hoist the frictional loss would be even less.

Yours very truly,

R. H. Beaumont.

R. H. Beaumont Co., Drexel Bldg., Philadelphia, Pa., Oct. 13, 1911.

Wood Block Paving on Street Car Tracks.

Sir: The following letter has been received by me relative to paving in city streets having railway tracks, suggesting an answer through the columns of Engineering News:

Rome Railway & Light Co.,
Rome, Ga., Oct. 13, 1911.

Mr. C. K. Mohler.

Dear Sir: In your report, which appears in Engineering News of Sept. 28, 1911, you show pictures of wood block paving in Chicago, which has

been badly worn owing to the presence of tie rods within the wood block paving.

I should like to ask your opinion as to whether there would be any objection, from the viewpoint of the street railway people, to having the tie rods come sufficiently low to allow the wood blocks to go in without being cut. Of course, it is easy to understand that tie rods are more efficient for holding track to gage when they are located high up in the web of the rail, but it would seem to me, that where the rail is partly surrounded by concrete, it would not sacrifice good construction, from the viewpoint of the street railway engineers, to locate the tie rods low enough not to interfere with the wood block.

I should very much appreciate your opinion on this question, either through a personal letter or through the columns of the Engineering News.

Yours very truly,
Samuel Young.

In reply to Mr. Young's request I will say that the points raised were treated on pages 28 and 29 of the report of the Loop Protective and Improvement Association, as follows:

LAYING BETWEEN THE RAILS OF THE CAR TRACK.—Perhaps one of the most aggravating obstacles to securing a uniformly good and even roadway surface is the street railway tracks. The paving inside the tracks and the outside junction with the rails is hardly ever found in good condition in a comparatively short time after laying. The paving between the track rails is subject mostly to the calking of horses' shoes. This is especially aggravated at points where the tie rods are located. A pavement on which can be seen much of the bad effects of this kind of wear may be found on Dearborn St., between Madison and Jackson. Wherever a tie rod occurs the spacing is apt to come out so as to require thin or narrow closures. Some of the narrow closure work was especially noted on the track laying on Monroe St., between Clark and Dearborn, during November, 1910.

It is believed that more satisfactory results might be had in the track paving if the tie rods were turned flatwise and thoroughly bedded in mortar so as to form a part of the paving bed. With a 3 or 3½-in. paving block the tie-rod space, or break, could be eliminated by laying the blocks continuously over the tie rods. As previously stated, the greater portion of the wear on the track paving comes from the calking in the transverse joints.

By laying the blocks lengthwise of the track the number of transverse joints would be reduced by fully one-half. In addition to that, those that do occur would be broken. I know of no case where these expedients have been tried. It is believed that some such method should be given a thorough test, at least to prove or disprove the theory. While the property owner does not foot the bill for the track paving, he certainly has a vital interest in the character of the roadway as effected thereby. The depth of blocks used in track paving in New York is 3 ins.

I might add that 4-in. depth blocks could just as well be used for the greater part of the work, and such depth for the blocks coming directly over the tie rods as any particular case demands. Thorough bedding of the blocks in mortar is recommended.

Charles K. Mohler.

Chicago, Ill., Oct. 16, 1911.

More About the Technical Graduate and His Compensation.

Sir: The letters and editorial comment in Engineering News of Oct. 5, concerning inadequate salaries paid to instrumentmen, and field engineers generally, brings to my mind a little piece of advice given to a group of young men, about to graduate from a course in civil engineering, by their professor, who was wont to give them good fatherly advice from his long and successful practice.

His remarks were substantially as follows: Never lower the dignity of yourself and of the engineering profession by accepting a responsible position with wholly inadequate compensation; if times are hard and work scarce and you must earn your bread and butter, do not be ashamed to take a rodman's job if it is all that offers. Under the circumstances this is no reflection upon you or your past work. But do not lose your own self-respect and discredit your alma mater and your profession by accepting a transitman's job at a rodman's salary.

It seems to me this contains a good bit of explanation why conditions in engineering work are what they are. There are yearly being turned loose many bright and capable young technical graduates, who through vanity to have high-sounding titles or eagerness to gain "experience," are willing to accept at starvation wages positions hitherto filled by older, more experienced and better paid men.

Doubtless many of these young men "make good" and fill the positions with fair success. But they have permanently lowered the compensation for that kind of a position. Sooner or later they see the point and we hear from them of the low salaries of engineers in contrast to their heavy responsibilities. Great numbers doing this same thing all over the country are the real cause of the present status of the engineer, not the employing engineer only.

The cure of the situation rests neither alone with employer or employee, but with engineers as a whole in their attitude towards what they are pleased to call a profession; but which very few employed engineers treat as a profession.

We know that, in a city where the regulation doctor's fee is $2 and some doctor comes in and accepts work at $1, he defeats the very object of cutting his rates; because people will not hire him; they do not trust him; there must be some reason for his cutting rates; in their minds the cost of medical services is associated with the quality of the same; they do not want a cheap doctor.

When the same feeling that cheap engineering is a poor quality of engineering permeates through the great mass of the people, we shall have the profession more nearly in the class with the other so-called learned professions.

The young engineer who accepts responsible work at insignificant wages generally does so because he believes the experience to be gained will partly compensate him. How often does the employer (I mean the business man back of the enterprise) realize that this experience must be gained at his expense? Yet every engineer knows of scores of blunders made by inexperienced men in responsible places, the cost of which would have paid the difference in salaries between experienced and inexperienced men several times over.

The employer is not apt to hear of these blunders because it is in the interest of all concerned not to advertise them. Instead of trying to shift the responsibility for the state of affairs upon his employers or upon his non-technically trained brethren the engineering graduate would do well to look his attitude towards his profession squarely in the face and see if *he* has done *his* part in maintaining its dignity.

"A Technical Graduate."

Brooklyn, N. Y., Oct. 12, 1911.

Concerning Instruction in Hydraulic Engineering; Ice Pressure Against Dams.

Sir: The timely article by John R. Freeman M. Am. Soc. C. E., in your issue of Oct. 19, on failures of dams, etc., suggests a few comments which may not be without interest.

Mr. Freeman calls attention to an evident deficiency in most of the text-books on hydraulics; but your readers who are not engaged in giving instruction should not conclude for that reason that the instruction given to engineering classes is deficient. In teaching hydrostatics it is the rule to call attention to the consequences of the principle of the equal transmission of fluid pressure in all directions, emphasizing its effect upon the stability of all structures which have to retain water. It is obvious that the mere mechanical conditions of stability, resistance to the overturning of the dam bodily about the outer toe, or the resistance of the material at the base to crushing due to the unequal distribution of pressure on the outer third, etc., are of rather secondary importance if hydrostatic pressure is transmitted to any serious extent within the mass of the structure.

It has been the practice of the writer to prepare a list of references of all of the most notable failures of dams, available through our engineering indices, and to assign these to members of the class to be carefully read and reported upon briefly, with whatever black-board diagrams are needed, at special class-room sessions. Mr. William R. Hill, in an address to the American Water Works Association in Chicago in 1902, gave brief descriptions of fifty failures of dams, and stated the fact that about forty-eight others had then come to his notice of which the records were not sufficient to permit any proper description of the structures or causes of the failures. In addition the writer has references to fifteen or twenty more, and now we have the instructive recent failures so fully described, bringing very striking lessons in simple confirmation of the truth of the old and oft-repeated principles which instructors have been trying to impress upon the minds of engineering students for the last quarter of a century.

We have always laid the strongest emphasis on the insinuating tendency of water and water pressure and its everlasting insistence by which it is ever working to get into the interior of the structure and so promote disruption. We often repeat the saying of Mr. McAlpine, that Nestor among the older builders of dams, who is reported to have said that the engineer must take every possible means to harass and impede the entrance of water to the interior of his structure; this by providing angles, projections and re-entrant spaces so that nowhere can the fluid find a direct path.

Mr. Freeman pays particular attention to the dangers to dams from the pressure of ice. While the writer has not now time to look up all the aforesaid references, he recalls but one instance where the failure of a dam was obviously and directly due to the push from the freezing of the water. This was the St. Anthony dam at Minneapolis in 1899. Mr. Hill gives three other instances where the pressure due to the freezing of water is supposed to have been the contributory cause with some others—as undermining and faults of construction.

It would seem that it would be impossibe for the engineer to expect to make his structure strong enough to resist the actual push resulting from the freezing of a large body of water at any cost which would be permissible. Without any thought of criticizing Mr. Freeman's views we assume that he calls attention to this danger so that the engineer may be prompted to adopt alleviating measures. For instance: spillway dams should be provided with a sufficient interior downward slope from the crest to allow the ice to rise by reaction on the inclined surface. Furthermore, as is well known, on all overflow dams the motion of the water flowing over the crest tends to hinder the formation of ice sufficiently to prevent any serious thrust. There is a distributing reservoir in northern New Hampshire in a very exposed locality, having a capacity of about one million gallons, where the formation of thick ice is prevented by having the water enter through a considerable number of small openings in pipes which are carried around the circumference and across the reservoir some five feet below the surface. This keeps the water so agitated that there are always open spaces just above the discharge orifices.

Robert Fletcher,
Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H., Oct. 21, 1911.

Curved or Straight Dams; Is Dam Design a Matter of Mystery?

Sir: One or two questions about the Austin dam may be worth further discussion.

1. Do the fractures in the larger broken pieces show that more desirable stresses would have resulted if the dam had been curved slightly upstream?

2. Is it possible that the resistance of the dam against sliding would have been greater if the cut-off trench just at the upper face had been omitted or excavated near the toe of the dam?

If the sandstone layers were nearly horizontal and pretty free from faults, the anchorage with iron rods would have been apt to transfer to the stratum in which the rods were sunk a part of the thrust that caused the dam to slide. The cohesive or tensile strength of that stratum may have been lessened by the construction of the trench along the upper face.

A sentence in your editorial of Oct. 5, does not seem to coincide with the writer's observation. You say: "There is no mystery in the art of dam construction." Evidently the word mystery means that which is not comprehended or well understood.

The statement is true of a number of engineering operations. If a plate girder has been built up and thoroughly tested and a hundred more just like it are needed, there would be little but routine work in providing them. But in many kinds of work, including docks, tunnels, large excavations, bridge piers and large dams many conditions and forces have to be taken into account. No two cases are alike, so that one cannot have the advantage of a real precedent; the relation of the engineer to the authority in control, the character of the workmen, the time interval, the material used, and even the weather and flood conditions have to be regarded. (Coroners' inquests often report that failure of an employe to do his duty or to obey orders is a mystery.) The result is that frequently new and complex relations are submitted to the good sense and judgment of the engineer. Such large operations are not always free from uncertainties and it is not always clear sailing, but it is engineering with its responsibilities, and with success or failure—to be determined by future occurrences.

H. F.

New York, Oct. 20, 1911.

[Those of our readers whose memories extend back to the controversy over the design of the Quaker Bridge dam proposed for the Croton watershed, may recall that the relative merits

of straight vs. curved dams were thoroughly threshed over at the time. While engineering opinion is still more or less divided, we believe the preponderance is now in favor of the curved dam. Mr. James D. Schuyler, in his treatise on "Reservoirs," says:

> It has been the observation of the writer that all curved dams are free from cracks, but that straight reservoir walls are quite certain to crack. The tendency of the water-pressure is to close any cracks that may appear where the dam is curved, and a curved dam is able to take up the movement due to temperature, without cracking, even though the pressure may not cause the arch to come in action. The inference is that every masonry dam should be built in the form of an arch, whatever its profile may be, for the avoidance of temperature cracks.

As to the effect of the cut-off wall in separating the rock layers and reducing the resistance to the sliding of the foundation itself, there may have been such an effect; but it would be wrong to argue that because of this the cut-off wall should have been omitted. It was necessary to do something to cut off the seepage of water through the station beneath the dam. A shallow cut-off wall was better than none at all. To have built a cut-off wall under the toe of the dam, however, would have rendered more certain the development of hydrostatic pressure beneath the structure.

We cannot agree with our correspondent that there is any "mystery" in the art of dam construction which should make such a structure any less safe than a plate girder. The routine work in building a plate girder represents a long chain of manufacturing operations from the raw ore to the assembled and erected structure. The chance of error at some point in the process which might produce steel of bad quality, or defective riveting or other weakness, seem to us fully as great as any difficulties which face the engineer who builds a dam. Of course, there are cases where the data of stream flow may be uncertain, or available materials may be unsatisfactory, or other unusual causes may make the design of a particular dam especially difficult; but we are speaking of dams built under ordinary conditions.—Ed.]

Report on Utilizing for Irrigation the Surplus Waters From the Los Angeles Aqueduct.

Sir: I am sending you a copy of a report upon the distribution of the surplus waters of the Los Angeles Aqueduct, which will not be immediately required for use within the present boundaries of this city. The report was prepared by a Board of Engineers appointed by the Public Service Commission of Los Angeles, consisting of Mr. J. H. Quinton, Consulting Engineer, U. S. Reclamation Service; Mr. W. H. Code, Chief Engineer in Charge of Irrigation for the U. S. Indian Bureau, and Mr. Homer Hamlin, formerly of the Reclamation Service and now City Engineer of Los Angeles.

The history of the growth of various towns in Southern California is interesting in that they all originated as irrigated agricultural enterprises, and by intensive cultivation built up a population approximating one inhabitant to the acre. These communities in their development are gradually furnished with all the conveniences of a modern suburban town, including electric lights, water under pressure, sewers and street-car facilities. The transition into urban conditions is gradual and normal. The districts become incorporated, commercial enterprises spring up, and the business block and factory develop in the midst of the community. As lands become more valuable for residential purposes, they are so used, and it is an interesting fact that the amount of water required for the domestic use of these town areas per acre is practically the same as that required for horticulture.

This was the original history of the city of Los Angeles. It was established by Spanish authority in 1781 as an agricultural colony, intended to furnish supplies for the Spanish army of occupation. The area set aside for the pueblo of Los Angeles apparently was closely fitted to the available local water-supply for agriculture in that district, and it was not until after the city had extended its boundaries materially, that this supply was found deficient, and it became necessary to obtain water from distant sources. The officials of the city government having the water question in charge, with wise forethought, determined to obtain as great a water-supply as possible from distant sources where the water was of minimum value, rather than to invade neighboring districts and, by condemnation proceedings, take their water-supplies which are now being used for irrigation in districts commercially tributary to the city.

In getting this large supply of water, the city is now enabled to assist in the horticultural development of a large territory surrounding its present city limits, and it is expected that as these areas develop, the boundaries of the city will gradually be extended so as to embrace them all. The city can then proceed with a normal transformation from agricultural to urban conditions, as existing conditions from time to time may require, and without shock to any of the regions concerned. It is, therefore, probable that the rapidly growing city of Los Angeles will become a still more important commercial center, surrounded by a highly developed horticultural region.

The Board of Engineers estimates that 135,000 acres of land can thus be improved. With this method of agriculture in the semi-tropical region surrounding Los Angeles, where citrus and other high-priced fruits are produced, it is conservative to say that the gross value per acre per annum of the crop will be $100. When this development reaches its perfection, this would mean an annual gross amount of $13,500,000, which would be widely distributed among a great variety of citizens, including laborers, commission merchants, transportation companies and ranch owners. This is equal to one-half the original cost of the aqueduct. The value of these suburban lands available for taxation, after they have been irrigated, could reasonably be taken as increasing from $100 to $1,000 per acre. Consequently, from a government standpoint, this feature is important.

The situation is unique and instructive, and offers a most interesting example of conservation, as applied by a municipality. In addition to this agriculture, there will be the most important element of supplying the city with an abundance of domestic water, as well as the generation of a large amount of electrical energy, which the city proposes to use for the public welfare.

Yours very truly,

J. B. Lippincott, M. Am. Soc. C. E., Assistant Chief Engineer, Los Angeles Aqueduct.

Los Angeles, Cal., Sept. 29, 1911.

[The pamphlet report (25 pp. and folding map) sent by Mr. Lippincott consists of a somewhat detailed study along lines indicated by Mr. Wm. Mulholland, M. Am. Soc. C. E., Chief Engineer of the Los Angeles Aqueduct, and also by Mr. Lippincott in notes presented for public discussion in Los Angeles and printed in our issue of Dec. 29, 1910. The same issue contained a similar preliminary discussion by Mr. E. F. Scattergood, Electrical Engineer of Los Angeles Aqueduct, on the disposition of the large amount of electrical power which the city proposes to develop from the waters of the aqueduct before they are dropped to the head required to supply the city by gravity. We also discussed this whole subject editorially in the issue named, giving Mr. Mulholland, his official associates and the citizenship of Los Angeles generally praise for the skill and the civic spirit shown in this unique municipal development.

The features of the report of most general interest, or the basic principles on which it is founded, are indicated in Mr. Lippincott's letter. In addition, the report advises that the supply of water to outlying districts should be conditioned upon annexation to the city, advance payments for the cost of local distributing systems, and annual charges for the water itself. Stress is also laid upon the necessity of storing the surplus waters below the terminus of the aqueduct.

Only tentative suggestions as to the cost of irrigation water to takers is suggested. The Board estimates an average first cost of $40 per acre for distributing works to supply a net irrigable area of about 103,000 acres, and seems to imply that the annual charge for water and water service might fairly be about $13 per acre. It is also suggested that either water-users' associations, like those under U. S. Reclamation Service projects, or irrigation districts, under the California (Wright) law, might be organized to meet the first cost of the distribution systems.

With the annexation to the city of territory irrigated by surplus waters and the gradual change of such territory from agricultural areas to city lots, the charges for water would change in character and method until they were made the same as those charged to residents of the present city.

Presumably anyone who can show a justifiable reason for wishing a copy of the report under consideration can obtain one by sending a 2-cent stamp to the Board of Water Commissioners, Los Angeles, Cal. The full title of the document is: "Report Upon the Distribution of the Surplus Waters of the Los Angeles Aqueduct. By J. H. Quinton, W. H. Code and Homer Hamlin, Advisory Engineers, Los Angeles, Cal., 1911."—Ed.]

The Danger in Using Rusty Steel in Reinforced Concrete.

Sir: In your issue of June 8, 1911, p. 684, the article by Mr. Harold P. Brown on the destruction of reinforced concrete in a refrigerating plant afforded the writer much food for thought. As written, the article shows that special destruction was wrought under special conditions in an especially short time by a large electric current assisting a fairly good electrolyte to produce both local pitting and general electrolytic corrosion.

It appears to me that too many engineers will dismiss this case from their minds with the idea that such corrosion will trouble only those who have to contend with similar special conditions. The intent of this letter is to show that actual destruction in this case is **an object lesson capable of the most general application to say and all reinforced-concrete work.**

The cracking and spalling of concrete, so well shown in the photographs, were caused by some pressure from within the beam or column, acting in an outward direction. This pressure is exerted by the so-called "rust" on the reinforcement. It is well known among engineers that iron products increase in volume when rust appears on the surface, that the rusting process continues so long as air and moisture can reach the iron, and that the rate of rust development depends on the porosity of the protective covering, as paint or concrete. There is no intention of claiming that rust is capable of self reproduction when air and moisture are both lacking, but after the first porous layer of red rust is pushed away from the iron by succeeding porous layers, a hard scale is formed which becomes black, and difficult to remove.

When paint or concrete is applied to steel in this condition, the cement or the paint is held in the pores of the outer layer of rust while the pores of the inner layers are filled with air awaiting the arrival of moisture through the pores of the protective covering, to form still another porous layer. The addition of the new layer to the volume of the rusty steel causes minute but gradually increasing cracks or openings in the covering which provide for the admission of increasing quantities of air and moisture.

There is a fairly prevalent belief that for concrete reinforcement a rusty rod is no more dangerous than a clean one; that rough handling shakes off all loose rust scale and what remains is tenacious scale to which, on account of its porosity and the pits in the rod, the concrete adheres better than to a clean rod. In effect, this is a belief that adhesion of concrete to thick rust is adhesion to the rod itself. The adhesion and the shearing strength of concrete is some 400 lbs. or 500 lbs. per sq. in. This represents the values used to connect the concrete to the rust on the steel. The value of the adhesion of the rust itself to the rod varies from nothing, in the case of the scale which falls off in rough handling, up to whatever amount is used in scraping and wire brushing. Surely we never apply 500 lbs. per sq. in. in the removal of rust scale by hand tools. The danger therefore lies in the rust which remains tenaciously attached to the steel.

Another prevalent belief is, that once concrete is outside rusty reinforcement, the reinforcement is protected for all time. This is an assumption that concrete is impervious to air, and water, and insensible to temperature, shrinkage, and normal load cracks. Yet we all know that after a couple of years minute cracks appear in all concrete, and articles have been written showing that capillary cracks occur on the tension side of concrete beams before safe loading has been exceeded and, moreover, one of the methods of showing such cracks was to soak the beam in water when it was deflected, remove the load and note the water lines where water was forced

out of the capillary cracks by the beam resuming its original position.

If concrete is non-porous, why use dampproof paints on the outside of foundation walls of concrete? On the average job, in order to ship in carload lots, about all the reinforcement is shipped at one time, and before the upper stories are reached several months elapse during which time the reinforcement is exposed to dews and rains unless special means to protect it are taken at the start.

Lead makes a good tight joint at first, in cast-iron water pipe and around foundation bolts until rust starts right at the masonry surface where moisture and air can reach the steel. This rust as it expands, wedges off the lead a little way and permits rust to follow down between the lead and the iron a little at a time.

Hand rails of a very poor quality of iron pipe are often used for small bridges, and this pipe is sometimes pitted with rust before being placed. The writer has tried the ordinary means of hand hammers and wire brushes on such piping to remove rust before painting. There still remained tight rust scale in the bottom of the pits. After a few months in a sub-tropical climate blisters appeared in the paint, which when removed by a knife showed that increase in the volume of rust had raised the paint, which being only less porous than concrete, had admitted moisture to the air already in the rust in the pits and paint blisters followed quickly.

About six years ago, covers for a steam conduit, in Brooklyn, were reinforced with iron and steel bars taken from a scrap heap and old stock. These bars were rusty; not a mere red dust such as appears after a few days exposure, nor yet the heavy thick scale with deep pits which are exhibited after some years' weathering. The rust was fairly thick and tenacious, in clinging to the iron.

After two years, some repairs showed that the bottom of these covers where they bore on side walls of the conduit were spalled off at each bar up to about the middle of the bar. The bars themselves had rust about ⅛-in. thick. The concrete was discolored and impregnated with black rust. This rust had matted over the line between the concrete and the bars so that it was impossible to see where the iron left off and the concrete began.

Steam was kept on these steam mains summer and winter. Between the side walls where the steam heat could keep the covers dry, moisture had not penetrated sufficiently to spall off the concrete from the bars. Beyond the effects of the heat, i. e., over the walls, 4 to 6 ins. from the sides of the cover, concrete was spalled off at each bar. The writer attributes the slower rusting of the rods in the middle of these covers to evaporation of moisture by steam heat and contact of concrete with heated air. Moisture passed through the sides of these covers until inside the side walls where it was free to drip downward or to evaporate

In the waters of New York Harbor, iron which is below low water, out of contact with air, rusts badly, and in fact wire screens made of No. 6 Government bronze wire have been destroyed in three years time. In other words, air occluded in water or contained in pores of concrete is sufficient for the production of rust. We know that New York Harbor water is a pretty fair electrolyte, but reference to it is proper in this case, for there is much steel in concrete which is immersed in this same water.

In spite of occurrences similar to those mentioned the rusting of reinforcement has not yet been taken up as a serious matter in construction work because ordinarily the process of destruction is very slow and as most engineers go from one construction job to another, we hear the excuse given: "I'll be away from here long before that gives out." The effect of rusting of concrete reinforcement has been pointed out in the columns of Engineering News in past years without attracting the attention it deserves, since the main purpose of the articles was not to call attention to the swelling properties of iron rust, and therefore this particular lesson was overlooked by many.

We are all familiar with the phenomena of water pipes bursting because of water freezing in them, we know just how much water expands in its transformation to ice, and articles have been written on the effects and the amount of the force of expanding ice. The reason we have taken up that subject so thoroughly is because of the short time it takes to damage structures in freezing weather. The rusting of steel and the consequent swelling of steel products is, when unassisted by electric current, a very slow process, but is nevertheless sure in its results. A parallel may be cited in the two diseases smallpox and tuberculosis of the lungs; the former quick and violent, the latter slow but sure in its effect.

After persistent search and inquiry for some years, the writer found that Mr. George Thompson, chemist of the National Lead Co., Brooklyn, N. Y., in a paper on "The Corrosion of Iron and Steel and Its Prevention," gives in an issue of the "Laboratory Bulletin" of Nov. 30, 1908, some computed figures for the increase of steel in volume upon its conversion into rust. These figures, 4.36 volumes of rust for each original volume of steel, are the only definite figures the writer has found. Many engineers have mentioned this increase as being very large but made no attempt to place a numerical value on it.

The necessity for securing actual contact of the bare metal with paint or concrete, and the various processes for the removal of mill scale and rust have been dwelt upon very largely. In spite of this, we have all seen concrete reinforcement being placed with a thick scale of rust all over it and yet the volume of a portion of that steel will in time become something like 4½ volumes of rust, forming under the concrete.

My attention was first called to rusting of concrete reinforcement by a letter to Engineering News, (some nineteen or twenty years ago) from an engineer in a tropical South American country who had attempted to build some massive concrete vaults, reinforced with some discarded tee rails, which we may be sure had the rust coming off in flakes. In about a year's time cracks appeared and the structure was ready to fall down. The engineer asked for similar experiences and a corrective process from other engineers, without any reply that the writer saw. His trouble was 4½ volumes of iron rust pushing concrete out of its proper place in the structure.

In Engineering News of Aug. 17, 1911, p. 207, there is a report of a committee of British engineers on the cracking of concrete caused by corrosion of the reinforcement. Since a committee was appointed to examine into concrete destruction, it appears that foreign engineers being accustomed to thoroughness have recognized the effects, and the dangers of corroded reinforcement, and also the wide distribution of structures in which engineers must prevent deterioration. In the examples of wharves given by the committee, it is noted that concrete cracked away from the reinforcement where the concrete cover was thinest; where air and moisture could reach the reinforcement by the shortest route; and where evaporation proceeded from the concrete surface at a slow rate; jarring of loads made no difference with the corrosion; the difference of potential given 0.11 volts, is to be found almost anywhere around cities between any two buried structures, and greater difference of potential occur in a dry soil where there is no electrolytic action; again, the important feature of the report is to the effect that below high water, where the piles have a good contact with the water, and where the electric current should leave the reinforcement and cause corrosion to be greatest, **no corrosion was noted!** This leaves open to consideration the causes mentioned in this article, i.e., common rusting where air and moisture can be supplied easily.

An article in Engineering News, of Aug. 24, 1911, p. 232, on "The Destruction of Masonry by Embedded and Attached Metal," from a paper by M. G. Denil, shows how foundation bolts in stone crack and split the comparatively non-porous natural stone, showing effects more quickly where the distance to the surface is small, that is, where the cross section of stone to be split off or sheared by the expansion force of the rusting steel is small. It is easy to see that concrete being weaker, and more porous than natural stone, should be given greater attention than natural stone, when steel is embedded in it, instead of less attention which is the usual case. In the article mentioned, particular attention is called to the following very pertinent remark which is equally applicable to concrete structures.

"Most of the structures in which iron is fastened to stone **will finally be ruined,** and the cause of the ruin may be attributed to the spontaneous expansion of the fastenings, on account of the oxidation of the iron."

In order to be sure that our concrete beams and columns will do their work not only "while we are here" completing the structure, but will do their work when "we won't be here" on this earth, we must be sure that "adhesion" is present and its opposing force, the 4½ expansion of iron rust, is absent. There is a simple remedy, so inexpensive that contractors are ordinarily perfectly willing to use it on the suggestion of the engineer. As cast-iron pipe now receives a protective coat by dipping, so should our steel be dipped for a few minutes.

To protect reinforcement from rust during the various delays between receipt of the reinforcement and its installation, the writer, has found it easy to coat it with pure cement grout. A shallow box a little larger than a sheet of expanded metal or a narrow trough sufficiently large to hold a few bars or a "unit" at a time will do the work. The grout should be mixed about as thin as a paint, the reinforcement soused into it several pieces at a time, and moved about enough to keep the grout well stirred. If the grout is too thick, the coating is too thick and is apt to flake off in handling. In a subtropical climate reinforcement was kept free from rust for over six months, and when used, the cracking off of the grout coating showed a clean metallic surface such as is desired to secure best results.

It is hoped that this letter may influence some to avoid the careless way in which they have in times past permitted the installation of rusty reinforcement, and thus postpone the date of "final ruin" of their work. Very respectfully,

L. F. Bellinger, M. Am. Soc. C. E. Civ. Engr.,
Philadelphia, Pa., Aug 29, 1911. U. S. N.

[If there were nothing to prevent the rusting of steel embedded in concrete save the adhesion of the concrete to the steel surface, then all reinforced-concrete construction exposed to the weather would be short lived. All concrete is more or less porous and more or less air and water can pass through it and carry oxygen to the steel. Many tests have clearly indicated that concrete exerts a chemical as well as a mechanical action to protect steel from rusting, and that this chemical action not only prevents rust from starting on a clean surface but prevents it extending on a rusted surface.

But it also appears that this chemical protective influence may be neutralized by the presence of an electric current on the reinforcement; by the presence of sulphur compounds in the concrete and very possibly by other influences not now known. If and when this chemical protective influence is neutralized and corrosion begins, the structure is endangered, for the expansive force of the growing rust, as our correspondent well shows, will inevitably disrupt the concrete if the corrosion continues unchecked.—Ed.]

Notes and Queries.

Secondary Stresses.—Errata.—In Mr. F. C. Kunz's article "Secondary Stresses," Eng. News, Oct. 5, 1911, pp. 397-402, several minor typographical errors in the mathematical work have been found, as follows:

p. 398, l. 14, "e = 0.29" should be "c = 0.29."

p. 399, l. 1 of eq. (3), the second term in the parenthesis should be $14.1 \frac{\phi_1'}{\phi_0'}$; the last part of the same line should read

$$\phi_0'' = \frac{960}{65.2} = 14.7$$

Mr. H. L. Handley, Yankee Fuel Co., Raton, N. M., would like to learn of the experience of other engineers regarding the use of rope grips, clamps or clutches and endless-rope car hauls on tramways having varying grades. He inquires what type of grip would be advisable with endless-rope haul for a 6,000-ft. inclined tramway with maximum grade of 21% and total drop of 600 ft., cars (weight, 2 tons each) spaced 300 ft. between centers.

In commenting on the Shuman sun heat engine in our issue of Sept. 21, we said "it would be surprising if a steam consumption of as low as 40 lbs. per HP. could be attained."

We have since received a copy of a test made by Prof. R. C. Carpenter on the engine referred to which showed a steam consumption per brake horsepower as low as 29 lbs. Considering that this steam had a gage pressure of only about 1 lb., with a condenser vacuum of less than 29 ins., and that the engine developed less than 20 H.P., the attainment of such a high economy is certainly a remarkable achievement in mechanical engineering. We are also informed that in later tests of the engine made by Mr. A. S. E. Ackermann of London, a steam consumption as low as 26.5 lbs. per HP. was attained.

The Salt Water Circulating System of the San Diego Electric Railway.

By L. R. W. ALLISON,* Assoc. Am. Inst. E. E.

The new power station of the San Diego Electric Ry., on Arctic and E Sts., San Diego, Cal., will eventually include an entire city block and will have a generating capacity of 35,000 KW., exclusively for railway service. In connection with this plant, the company has constructed a sea-water condenser-circulation system which shows interesting and distinctive features.

Water is taken from the Bay of San Diego, some 250 ft. out from the shore line. The circulating system, exclusive of what may be called power-plant piping and apparatus, comprises two 706-ft. lines of 60-in. reinforced-concrete pipe, with reinforced-concrete intake and terminal chambers. The general plan and profile are shown in Fig. 1 and a larger-scale plan in Fig. 2.

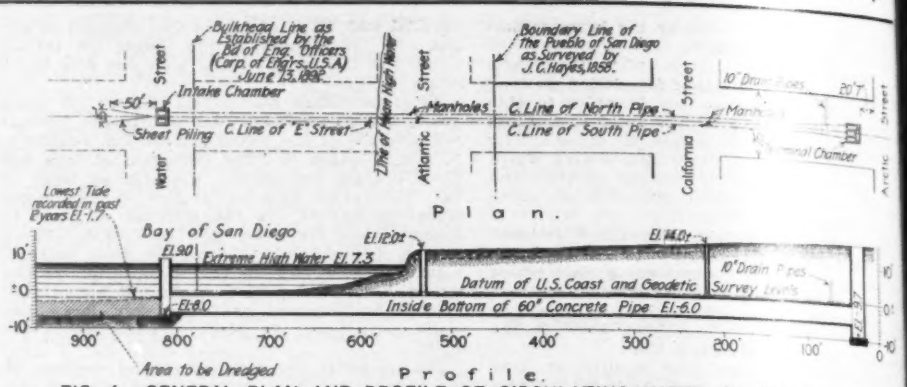

Bulkhead Line, as Established by the Bd. of Eng. Officers, (Corp. of Engrs. U.S.A.) June 13, 1892.
Boundary Line of the Pueblo of San Diego as Surveyed by J. C. Hayes, 1858.
Intake Chamber
Sheet Piling
C. Line of "E" Street
Manholes
C. Line of North Pipe
C. Line of South Pipe
Water Street
Atlantic Street
California Street
Arctic Street
Plan.
Lowest Tide recorded in past 8 years El. 1.7
Bay of San Diego
El. 9.0
Extreme High Water El. 7.3
El. 12.0±
El. 14.0±
Datum of U.S. Coast and Geodetic
Inside Bottom of 60" Concrete Pipe El. -6.0
Area to be Dredged
Profile.

FIG. 1. GENERAL PLAN AND PROFILE OF CIRCULATING-WATER INTAKE SYSTEM; SAN DIEGO ELECTRIC RY.

INTAKE CHAMBER.—The intake chamber is located near the bulkhead line, at the foot of E St. It is divided into two compartments, one for either pipe line, each with inside dimensions of 6×7 ft., with 17 ft. clear height, extending 1.7 ft. above the highest water line ever recorded. The chamber was constructed inside a timber cofferdam, the footing being 10 ft. below the ground surface, resting on a quicksand bed without piling. Canvas covering and a pumping plant were used to secure an initial settlement. The footing is 13×22 ft., 24 ins. thick, reinforced with ¾-in. twisted rods at 12-in. centers, each way. The outside walls vary in thickness from 24 ins. at the base to 18 ins. at the top, with horizontal and vertical reinforcement of ½-in. twisted rods, 8 ins. on centers. The 12-in. partitioning wall is similarly reinforced. The chamber is covered on top with 2×12-in. wood planking, and is provided with ladders, handrail, etc.

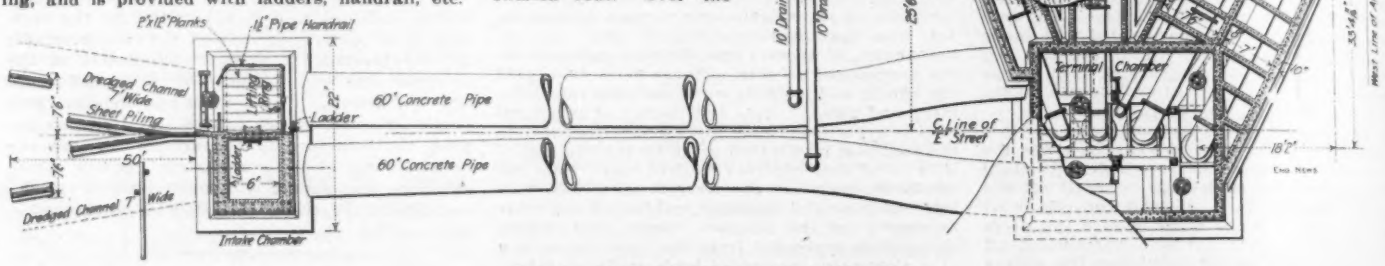


FIG. 2. PLAN OF PIPES AND CHAMBERS.

A sectional elevation is shown in Fig. 3. While this chamber has been called an "intake" it is obvious that it serves as both intake and outlet.

TERMINAL CHAMBER.—The terminal chamber is coincident with the center line of E St. adjacent to the west side of Arctic St. It is 18 ft. 3 in. × 20 ft. 3 in. inside and approximately 24 ft. high. The footing, 11.7 ft. below datum, is identical in construction with that of the intake chamber. The exterior walls are 24 ins. wide at the bottom diminishing to 12 ins. at the top, with reinforcement of ½-in. twisted rods, horizontally and vertically, varying from 6-in. to 12-in. centers, shown in the cross and longitudinal sections, Figs. 4 and 5, from which other features may also be observed. The chamber is covered, with the exception of the manhole portion, by a 6-in. concrete slab with girders and reinforced with ½-in. twisted rods at 4-in. centers, interlaced with ¼-in. ones, 8 ins. apart. The girders range in size from 6 × 12 ins. to 8 × 16 ins., each provided with two reinforcing rods bearing upon 8 × 8-in. posts, with ½-in. twisted rods. Over the manhole openings, 12-in. × ½-in. steel cover plates are used, riveted to 4×3×⅜-in. angles.

This chamber is connected to the power house by four tunnels crossing at right angles to the pipe line, the distance being about 29 ft. The smallest two tunnels are 5 ft. 6 ins. wide, with an arch height of 6 ft. 9 ins. radius, the others being 7 ft. and 7 ft. 6 ins. wide, respectively, and of the same height. The footing is 6 ins. thick, reinforced with ½-in. twisted rods placed 12 ins. on centers; the walls vary in thickness and reinforcement, and, in company with the 6-in. overhead slab construction, will be noticed in the plan, Fig. 2, and in the sectional views, Figs. 5 and 6.

The concrete for all the work mentioned was a 1-2½-4½ mixture, machine mixed and thoroughly puddled; the various materials, cement, sand and stone, were graded by the usual standard specifications. The forms were wired together and the work was carried on in sections. After removal of the forms, the exposed face of the concrete was washed by a finish coat of thin grout, applied with a brush. Where waterproofing was desirable, 10% hydrated lime was added to the concrete during mixing.

*1353 West 30th St., Los Angeles, Cal.

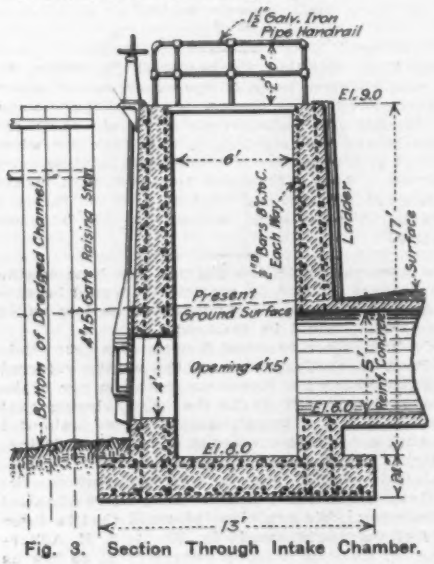
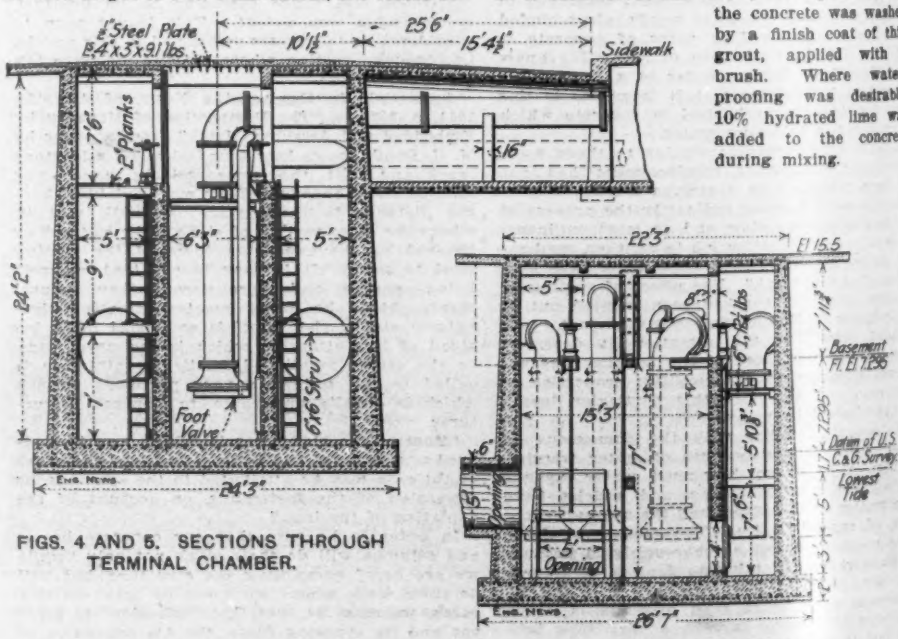


Fig. 3. Section Through Intake Chamber.



FIGS. 4 AND 5. SECTIONS THROUGH TERMINAL CHAMBER.

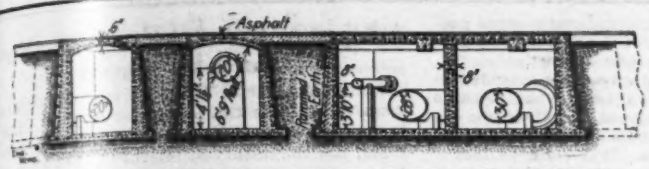


FIG. 6. CROSS SECTION OF PIPE TUNNELS FROM TERMINAL CHAMBER.

PIPE LINE.—Two lines of 60-in. reinforced-concrete pipe, in 3-ft. lengths, were laid between the two chambers, each line being 766 ft. long. The pipe was placed with the inside bottom at a depth of 6 ft. below datum, as shown in the profile, Fig. 1. All excavation work was executed in open cut with orange-peel buckets; the sides of the trench were supported with 4-in. tongue and groove wood piling, with posts where required, and braced by means of 8 × 8-in. timbers. The pipe was a standard type of the makers, composed of a 1-2-3 mixture, each section reinforced with seven ⅜-in. corrugated steel bars about the periphery, and with five ¼ × ¾-in. flats, longitudinally, the latter having hooked ends. The respective flats were interlocked at the joints by 1 × ⅛-in. bands. An exterior cement wash coat was given. The joints between the pipe sections were the usual type of the makers. A galvanized joint shield was placed about the outside of the connection, and a thin 1-2 liquid mortar poured, care being used to completely fill the space.

The pipe was laid on 7-ft. centers, giving a clearance of 12 ins. Where possible it was placed directly upon the sand as a foundation bed, but the nature of the soil, for the most part, demanded the employment of additional footing. For this purpose two 8 × 8-in. stringers, beveled on one edge, were used beneath each line, these resting on 3 × 3-in. redwood mudsills, set on 3-ft. centers. This is shown in Fig. 7. In one section, where the excavation had been made too deep, piles were needed; they were driven 2 ft. apart, and the stringers were increased in size to 8 × 10 ins.

Concrete manholes were constructed at the intersections of California and Atlantic Sts., as shown on the profile. These were 3 × 3 ft. inside, with 12-in. walls reinforced by ½-in. twisted rods, 12 ins. on center, both horizontally and vertically. Each manhole was provided with an iron ladder and a heavy cast-iron cover. A sectional elevation is shown in Fig. 8. Two 10-in. cast-iron drain pipes were located about 25 ft. from the nearest wall of the terminal chamber, one for either line of pipe. The flange connections were secured by partly imbedding a short double-flange connection in two lengths of reinforced-concrete pipe during manufacture at the factory yard.

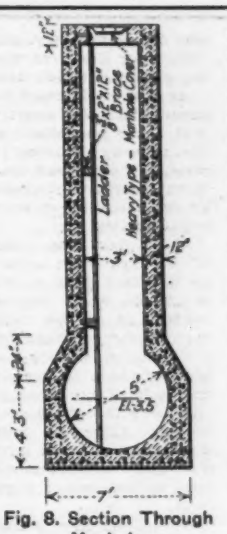


Fig. 8. Section Through Manhole.

OPERATION. — The compartments of intake and terminal chambers are provided with 4 × 5-ft. openings at levels suiting the pipe. Each aperture is fitted with a cast-iron sluice gate, with rising operating shaft. Those at the intake end have a wheel stand outside the chamber, while at the terminal chamber they are operated from a platform 17 ft. above the bottom. It is seen that the valves here are arranged so that the various suction and discharge pipes can be thrown into communication with either sea pipe.

Beyond the intake, a channel has been dredged, for each line, 7 ft. wide and to a depth of 7 ft. below datum; also a row of 12-in sheet piling, with 4 × 6-in. waling strips has been driven for a distance of 50 ft., coinciding with the dredged area, commencing at the dividing wall of the chamber and terminating 15 ft. apart, as shown in Figs. 1 and 2. This piling is to prevent by-passing water directly from discharge to intake pipe.

The company plans to alternate the service of the respective lines, employing each as intake or discharge, as the case may be, for a period of from three to four weeks, and then reversing the flow. The terminal chamber has been designed for this condition, as well as for the temporary closing of either line, through necessity for repairs or the like. By interchanging the current it is expected that material assistance will be rendered in keeping the line free from seaweed and other marine substances, which have caused difficulty in the operation of salt-water suction lines in semi-tropical regions like this. On account of frequent reversal of flow, the sea pipes are laid on the same level. It is hardly necessary to note that the pipes in the short tunnels from the terminal chamber lead to and from two large pumping units, supplying the condensers.

The installation of this system cost approximately $80,000. It was designed by Mr. A. Ervast, Chief Engineer for the San Diego Electric Ry., and the plans and specifications were prepared by the engineering department of the company under his supervision. Mr. Ervast also personally superintended the construction, giving lines, grades, etc., for its performance. Mr. C. W. Corbaley, Los Angeles, Cal., to whom the writer is indebted for much of the foregoing information, was awarded the contract for the entire work, exclusive of supplying the concrete pipe and sluice gates, at a price of $56,000. For the class of work, rapid progress was made, pipe laying at times reaching a total of 100 ft. a day. The pipe was furnished by the Reinforced Concrete Pipe Co., of Jackson, Mich., under the direct charge of the Los Angeles branch which had a representative on the ground to supervise the laying.

FIG. 7. REINFORCED CONCRETE PIPE-LINES IN CONSTRUCTION.

The Berlin District for Transit, Parks and City Plan.

A special metropolitan district for Berlin is instituted by a new Prussian law which takes effect April 1, 1912. It is to have jurisdiction in matters of transit, street layout and city plans, and parks. A summary of its scope is given by J. Stübben in "Zentralblatt der Bauverwaltung" of Sept. 13, 1911, from which we take the following notes.

The district is formed of the "Kreise" Berlin, Charlottenburg, Schöneberg, Rixdorf, Wilmersdorf, Lichtenberg, Spandau, Teltow and Niederbarnim. It is to be governed by an assembly of 100 members elected for six years by the local councils, and a council of 19 members, eight of these being elected by the assembly. The Oberbürgermeister of Berlin presides over both assembly and council. A district manager (and if necessary other administrative officials) is elected by the assembly, subject to the King's approval. The district may levy assessments on its component elements, to pay the costs of the work it undertakes. Its spheres of work are:

TRANSIT.—The district may buy, build, or operate railways, or may let out their operation to private parties; it may use the public streets for this, on paying compensation. It has the power to take over the railways of the towns or "Kreise" included in the district, for compensation, even without the owners' consent. The rights and obligations of private railways to the public will in future be centered in the district government. Further, any future town or "Kreis" railways must be sanctioned by the district.

STREET AND CITY PLAN.—Street lines may be fixed by the district, so far as necessary for creating or improving thoroughfares, for railway operation, or for the creation and control of open squares or parks. The district also has a more general jurisdiction over street lines and city-plan projects in open territory, whenever the interests of traffic, housing, or municipal hygiene are touched.

The latter provision, inserted by a special amending clause, for the first time provides a supervisory and directing authority over city planning in the metropolitan area of Berlin.

The Prussian Minister of Public Works has approval authority over acts of the district under the head of City Plan. The actual execution of work under this head is laid on the local authorities, unless with consent of the latter the district undertakes to do the work.

PARKS.—The district has jurisdiction over the creation of parks and playgrounds, and also over their improvement, maintenance and use. It may turn over the maintenance to the local authorities for due compensation.

Recommendations of Col. Geo. W. Goethals, Chairman and Chief Engineer Isthmian Canal Commission.*

The estimated date for the completion of the canal was based on the report of the International Board of Engineers submitted in 1906, and was fixed at Jan. 1, 1915. In the meantime, the work advanced more rapidly than had been anticipated, and it became apparent that it would be possible to pass vessels through the canal at least a year earlier than this date.

Becoming aware of this contingency and realizing the necessity for commerce to adjust itself to the new conditions, the shipping interests of the world raised the question of canal tolls in July, 1910, and urged an early settlement. Attention was called to the fact that at least 18 months' notice of the rates should be given in order that steps might be taken in time to change routings that would follow if the canal were used. If rates are such as to warrant the adoption of the new route, commerce will adjust itself to its utilization as soon as possible; if not, the old channels will continue to be followed.

Inquiry not only confirmed this statement, but developed the fact that the organization of new companies for use of the canal was contemplated, provided the established rates should be sufficiently attractive. It was developed, also, that two years' advance notice was desired in order to permit the building of the necessary ships.

To determine, then, the approximate date when the canal would be ready for use, and to report what steps, if any, should be taken to expedite the work, a board was convened, composed of those charged with the work in progress and contemplated. Based upon the report of this board, announcement was made that all the concrete in the locks at Gatun would be laid by June 1, 1912, and in the locks on the Pacific side by Oct. 1, 1912; that, assuming the gates were completed by June 1, 1913, as stipulated by the contract, the locks would be ready for use on this date if the operating machinery were installed; that the work on the spillway at Gatun would be completed to the elevation of 50 ft. by April 1, 1912, and the entire dam would be finished by the close of the dry season of 1912-13; that the excavation through Culebra Cut would be completed by July 1, 1913, if no more material due to slides had to be removed that was estimated at that time; and that the exterior channels would be sufficiently advanced to pass the shipping that would use the canal.

A year has elapsed since the report upon which the statements heretofore made were based, and though an increase due to slides was made in the estimated amount of material to be removed from the Culebra Cut, this increase gives no grounds for changing the date. Moreover, after the completion of the locks, dredges can be passed into the cut and the remaining material can be removed more economically and to better advantage.

Though the Division Engineer cannot complete all the concrete work on the Gatun Locks by the time first estimated, and now fixes the date as Jan. 1, 1913, this will not interfere with the erection of the gates (the concrete needed for this purpose being practically in place) nor cause any delay to the work as a whole. Progress made in the construction of the dam confirms the promise of its completion. The Division Engineer adheres to the date heretofore announced for completing the locks on the Pacific side. The erection of the gates has not progressed as contemplated by the contract, but the shopwork is well advanced and by increasing the erecting force there should be no delay on this account. The Assistant Chief Engineer has taken all steps necessary to insure the delivery and erection of the operating machinery and lighthouses, and anticipates completing them on time. The contract recently made for the emergency dams calls for completion of the last one by June 15, 1913.

The need for legislation looking toward the fixing of tolls is therefore urgent. Time can be saved in making public announcement of the rates to be charged by compiling, in advance of legislative action, the data of the amount of traffic that will probably use the canal and the formulation of rules by which the tonnage of ships is to be determined. Steps to this end have been taken.

Another matter needing attention is the organization for the operation of the canal and for the government of the Canal Zone. These two are intimately connected. Existing law provides for the construction of the canal; also for the exercise of the military, civil and judicial powers necessary for the government of the Canal Zone during a period which has already elapsed.

As the work nears completion, it is intended to concentrate the construction until what remains will be in immediate charge of the directing office, thereby reducing the costs and, so far as possible, the overhead charges. It is believed that a more satisfactory operating force can be secured by the selection of suitable men from the present organization.

There has been considerable criticism because of the high wage scale that exists, but this is due to the fact that it was difficult to obtain men when the work started, on account of the bad reputation of the country, and also because of the temporary character of the work. Complaints are made constantly because the salaries are disproportionate to responsibilities, and because of the lack of uniformity in the percentage of excess over the wage scale for similar labor in the States. After the inauguration of the scale it was not considered advisable to make any reduction, and rearrangements were made from time to time as necessities required, but inequalities still exist.

Conditions are different now. The chief sanitary officer declares the death rate of the zone to be "much lower than that for most parts of the United States," and the general health of about 8,000 white Americans in the zone to be "fully as good as it was in the United States"; also, continuance in employment can be assured. It is believed that a lower wage scale can be put into effect for operating the canal, and that the necessary force can be secured from the men who will remain in the service during the next year or two. This is an important consideration, since it is essential that the cost of operation shall be reduced to a minimum consistent with efficiency. With the operating organization provided for, steps can be taken to adopt a salary and wage scale, after which there can be created from the construction force one for operation, without delay or confusion.

Assuming that the canal is being built for the benefit of the commerce of the world, it nevertheless is a military asset to the United States and conditions may arise in which the military necessities of the Nation will become paramount. It is essential, therefore, that an entity should be established or created and so organized that any contingency can be promptly met as soon as it arises. In other words, while during certain periods the operation of the canal is for commercial purposes, entirely separate and distinct from the military, there are times when the military necessities must predominate.

Every known precaution has been taken to insure the safety of the locks. Accidents to locks have in nearly every case resulted from misunderstood signals in the engine room. To avoid any possibility of accident which might render the canal useless, the authorities should assume charge of all vessels during their transit of the locks; under such conditions any damage that may result to the vessels should be assumed by the Government, and legislation looking to this end is necessary.

The revenues of the canal should go to pay not only the operating expenses, but to repay the capital invested. Every legitimate means for increasing the revenue should therefore be adopted. The Government should have coal and fuel oil on hand for its own vessels, and these commodities should be sold to shipping using the canal. These should be supplied at an established rate and purchased after advertisement. The existing commissary, manufacturing plant, and laundry should be continued for the benefit of Government forces and to furnish supplies and service to shipping. A wireless telegraph station should be established for commercial as well as military purposes.

The canal authorities should be authorized to sell tools and appliances needed by ships, and to make repairs as may be necessary while ships are in the vicinity of the canal. A dry dock should be built with dimensions conforming to the locks. Both the dry dock and machine shops should be available for use by the Navy. If this policy is to be adopted, early legislation is needed in order that the construction necessary to make it effective may be undertaken without delay.

*In the Annual Report of the Isthmian Canal Commission.

An International Exhibition of the products of various industries, agriculture and the arts and exhibits illustrating progress in methods of instruction, hygiene and sports will be held at Sofia, Bulgaria, from June to September, 1912. Full particulars may be had by addressing the Organization Committee, International Exhibition of 1912, 5 Alexander Place, Sofia, Bulgaria.

A Report by B. J. Arnold on Traffic Congestion in Los Angeles.

The congestion of street-railway traffic in Los Angeles, Cal., is the subject of a report by Mr. B. J. Arnold, of Chicago, to the City Council. He found the congestion of interurban and local surface cars on Main St., in the center of the city, worse than in any city which he had visited. Fully 50,000 passengers were being delayed daily from 5 to 45 minutes each, in the rush hours due to fundamental defects in the transportation arrangements on this street. As many more passengers were being inconvenienced in other hours. At the same time he found both a temporary and permanent remedy easy to apply.

There is a stub-end suburban terminal at Sixth and Main Sts. arranged so that the incoming track from the north intersects the outgoing track to the south. All entering and leaving tracks have curves on Main St. where there is a heavy vehicular traffic to interfere with quick exit and entrance of cars. The loading facilities are not designed to handle crowds; as the schedule becomes disarranged passengers have to stand before a gate until the given route is called, when there is a general scramble.

The interurban cars issuing from the terminal have to take their place in a string of local cars on Main St. stopping at every street intersection. The alternation of cars from different lines prevents sending them over the crossings in bunches of two or more and, as it is not easy to tell whether a car is to go straight ahead or turn, vehicular and foot traffic is also greatly delayed and inconvenienced. At one place, Main and Third Sts., an intersecting line becomes a part of the main line for a short ways. The delays are doubled here by a track construction which permits passing only one car over the intersection at a time. The delays pointed out become cumulative and the first delayed cars pick up a large share of the rush-hour travel, so that on each route a few heavily loaded cars are followed by light ones. The schedule provides a sufficient number of seats, but the Main St. delays reduce the capacity of the system when it should be at its maximum. The traction company was not blamed in Mr. Arnold's report, as he found the conditions described the result of the remarkable growth of the city. Moreover, the system had a greater capacity than designed for.

For permanent relief Mr. Arnold suggested a subway, open cut or elevated structure to take the suburban cars off the street grades. As design and construction of such a line would require several years, a temporary relief was offered in opening a mile-long parallel two-track line along San Pedro St. for the interurban cars. Difference in street levels at the terminal allowed seven extra loading tracks and chance for better waiting facilities. These extra tracks provided storage space for cars to be sent out in place of delayed incoming cars to maintain the schedule. There was also chance of slower loading of cars so that passengers could wait seated in the cars rather than standing herded before the gates. Some minor rerouting was suggested to avoid curves at street intersections in the downtown district.

Mr. Arnold considered the building of the double-track line on San Pedro St. as the first step to the construction of the proposed municipal railroad. It was pointed out that spur connections were possible to the Southern Pacific Ry. so that carload freight could be collected and delivered at night along the length of new line, opening up a central district, nearly a mile long, well adapted for factories and warehouses, but now dependent for freight service on trucks and teams. A feature of the report touching on this development was the proposed crossing of this mercantile area by viaducts carrying street cars and vehicles.

It was reported that possible joint use of the proposed San Pedro St. line by the interurban brought unique franchise problems. There were two possible plans reported for the franchise and financial arrangement. The first provides for immediate municipal ownership, the city building the tracks and renting them to the Pacific

Electric Co. for the present. The second scheme provides for ultimate municipal ownership, the company building the tracks but under agreement (1) to sell to the city at cost at any time and (2) to withdraw its suburban cars from the street levels as soon as a permanent elevated or depressed right-of-way can be provided. Mr. Arnold suggested that either plan would work satisfactorily and that it was more important to secure the result than to fix the means.

Electric Drives for Screw-Propellers.*

By H. A. MAVOR.

The problems of marine engineering have until recent years been solved exclusively by the application of various forms of the reciprocating steam-engine, and the power, speed, form and general arrangement of power-driven vessels have been developed in connection with this means of propulsion. The advent of other appliances has opened up new lines of development, and in certain departments there is evidence of need for intermediate devices between the power-producing and the power-absorbing elements.

The necessity for these devices arises when the properties of the propeller in respect of rate of revolution are incompatible with those of the power generator. This incompatibility is most conspicuous in vessels which have to operate at relatively slow speeds. An examination of the conditions which have emerged in the development of marine propulsion soon shows that the incompatibility is not accidental, or due to imperfections in the design, construction, or use of the propelling equipment, but that it is associated with the essential properties of the substances and appliances with which we have to deal.

It may be said in general terms that high efficiency is associated with low rate of revolution of the propeller, while in the steam turbine high rates of revolution are essential to the most economical use of the steam. Internal-combustion engines have speeds more nearly approximating those of reciprocating steam engines, but here also there is a tendency to speeds higher than are convenient or economical from the propeller standpoint.

In addition to those fundamental incompatibilities arising from causes out of the reach of direct accommodation, there are other conditions which limit the direct application of engine to propeller. The draft, beam and form of the vessel limit the area of the propeller. The traffic for which the vessel is designed influences the determination whether one, two, or more propellers are to be used, and the speed, size and form of the vessel determine limits to the designer's choice. All these considerations taken together frequently fix the diameter, pitch and thrust of the propeller within narrow limits and also the rate of revolution. Now this rate of revolution is not always the most favorable for the power-generator, and the designer is in such cases compelled to resort to new expedients if he is to attain the standard of efficiency in power generation which has been set by the results attained on land. At the present moment the economy of power production in the best practice on land is considerably in advance of what has been done at sea. The principal reason for the better economy of the land work is the higher rate of revolution of the power-generator when untrammelled by propeller conditions.

There are cases where the special limitations in respect of dimensions and weights permissible for the machinery are such as to preclude the use of any intermediate mechanism between the prime mover and the propeller. In a ship whose voyage is short, whose speed is high, displacement small, and the propeller efficiency as good as is attainable, and the quantity of fuel carried small relative to the weight of machinery, the possible economy in fuel may be insufficient to warrant any increase in the weight of machinery; or, to put the case otherwise, it is advisable to sacrifice economy in fuel to keep down the weight of the equipment—e. g., a vessel running one-day voyages, and burning 50 tons of coal, could not possibly submit to an increase in weight of machinery in excess of the coal-saving, because such increase would increase the displacement and the power necessary to drive the vessel. If, on the other hand, the vessel makes a ten-day voyage, and the saving in fuel carried amount to ten tons per day, a considerable increase in weight of machinery might be associated with decreased displacement and a substantial all-around economy.

Various methods of making the required adaptation of generator to propeller are at present under trial. Mechanical gearing by toothed wheels and hydraulic transmission may be considered serious competitors of electric transmission, but for large powers it seems reasonable to expect that electric transmission, which is already developed for this very purpose on land, is likely to find an equally useful field where the conditions are such as to require an intermediate device at sea.

The cost, weight, and efficiency of electric transmission compare favorably in the examples which have been examined with either of the two competing methods. There are other important qualifications of electric transmission in which it stands altogether unrivalled. It provides a ready means of reversing the direction of rotation of the propeller without changing the direction of rotation of the power generator. The electric transmisson also provides means for changing the speed ratio between generator and propeller, so as to permit of the power of the generator being developed under the most favorable conditions at all speeds of the ship. Lastly, it provides means for applying the power of one or more engines to one or more propellers, so that the power-generating units may be so disposed as to give the highest efficiency, and when they are not required they can be stopped.

These properties of the electric transmission supply exactly what is required to render steam turbines, and also internal-combustion engines, completely adaptable to the purpose required. Both types of power generators give their best efficiency when full speed of rotation is maintained, even when running below full power. It is, therefore, advantageous to keep the engine revolutions within the range of governor control, while the required speed change is accomplished by electric combinations.

The properties of the electric motor lend themselves well to the requirements of manoeuvering. The rate of reversal is under perfect control. The possibilities of rapid and certain action are more than are attainable in a reciprocating steam engine connected direct to the propeller, and the electric-motor is applicable to powers for which there is no possibility of using anything in the nature of reversing gears or clutches.

The property of combining the power of more than one engine for application to one or more propellers is the special feature of the author's invention as distinguished from the ordinary methods of electrical engineering. Engines of different types, sizes, and rates of revolution can have their powers combined without interconnection of their electric circuits, and without risk of mistake or error. An oil engine at 100 r. p. m. may be running the vessel at slow speed, and a steam turbine running at 20 times the speed may be jointly applied to the propellers without any complication of the electric equipment. Each unit does its own work independently.

The advantage of such an equipment in vessels which are required to operate under varying load conditions is evident. Without subdivision of the power units, the whole of the main machinery must be in motion while the ship is in motion. At speeds reduced below its normal rate of revolution the steam turbine is less economical than the steam engine. Subdivision into high-pressure, low-pressure, and intermediate elements has been carried out, in certain steam equipments, but this results in a somewhat complicated and inconvenient system of piping, because the steam has to be led from one part of the system to the other across the vessel. In the electric system each unit can be self-contained, and disposed in the manner best suited to a convenient arrangement of the engine room. The size of the individual units can be adjusted to suit the powers required at the different working speeds, or they may be duplicate.

A few examples of application of the system are here presented, together with a description of a small vessel built to demonstrate and illustrate the principles of operation and to provide experience in the use of the plant. In all cases alternating three-phase current is used, and interlocking devices connect mechanically the main reversing switches with the existing switches, so that no change can take place in the connections while they are passing currents.

Turbo-Electric Steamship "Frieda."

This vessel has been specially designed for the transport of bulk freights between the Gulf of Mexico and New York City. The vessel is to be 300 ft. long, and will carry a dead-weight of approximately 5,000 tons, at a mean loaded speed of 12 knots at sea. The propelling machinery is aft, and consists of a turbo-electric outfit for 1,500-KW., three-phase, 50 cycles when running at 3,000 r. p. m. The turbine is supplied with steam at a pressure of 200 lbs. per sq. in. at the turbine stop valve. This electric generating plant is arranged on foundations on a platform deck in the engine-room hold. The condenser is fitted with a vacuum augmenter, and is suitable for dealing with the full-load quantity of steam from the turbine. The vacuum obtained will be 28½ ins., with cooling water about 85° Fahr. This condensing plant consists of a vacuum condenser, three-throw air-pumps and centrifugal circulating pump with electric-motor drives. The current is led to a three-phase motor, which is keyed direct to the main propeller shaft, and is capable of developing 1,900 B. HP. at a speed of about 84 r. p. m. The steam is generated in two Scotch boilers, with Howden's forced draft, and liquid-fuel burners. This installation costs and weighs less than the normal equipment. The coal saving is over ten tons per day. The design of the ship itself presents many other novel features. This design was prepared by Messrs. John Reid and Co., 17 Battery Place, New York City.

Oil-Electric Tank-Barge for Canadian Service.

In this the system is applied to the propulsion of a 245-ft. Canadian canal-type tank barge for the Standard Oil Co. The equipment consists of three separate units of Diesel non-reversible oil engines, each capable of developing 200 shaft horse-power, each directly connected to an alternating-current generator. The currents from one or all of the units are led to the separate windings of a three-phase motor, keyed to the main propelling shaft and operating a single slow-turning screw. The great advantage and economy of this system consists in being able to run at full power or at one-third power using one or three engines at full-load economy at will, thus providing for an economical operation impossible with any other propulsive system. The fact that non-reversible oil-engines are used running under governor control greatly simplifies the maintenance and operation. The control is operated by a low-tension interlocking switch, operated by an ordinary engine-room telegraph stand located in the pilot house, so that manoeuvering of the vessel is at all times in the hands of the navigation officer. This equipment increases the cost of the ship about 10% above the normal, but the carrying capacity is very largely increased.

Marine Turbo-Electric Installation Proposed for U. S. Navy Colliers.

A marine turbo-electric installation has been submitted to the U. S. Navy Department for adoption in one of the four large colliers recently given out to contract. The installation consists of a 5,000-KW. steam turbo-alternator with condensing plant. The current is led to two motors, one being keyed to each propeller shaft. The machinery is right aft in the vessel. The steam is generated by Scotch boilers. The vessels in which it is proposed to install this machinery are 525 ft. long, and will carry a dead weight of 12,500 tons of coal at a speed of 16 knots at sea. Here, again, the cost, weight and economy are better than can be shown with the normal reciprocating-engine equipment.

Prizes for Essays on economic subjects are offered for the eighth consecutive year by a committee of which Prof. J. Lawrence Laughlin of the University of Chicago, is Chairman. Four prizes are offered, amounting in the aggregate to $2,000. Circulars setting forth the conditions governing the award of the prizes can be obtained by addressing Prof. Laughlin. These prizes, as heretofore, are given by Hart, Schaffner & Marx, of Chicago.

The Project for Municipal Water-Works for San Francisco, Cal., is making headway. The city has recently ordered the completion of the purchase of lands owned by Mr. Wm. Hammond Hall, M. Am. Soc. C. E., in Cherry Creek. This, we understand, gives the city complete ownership of all lands and rights in the Lake Eleanor and Cherry Creek sections of the proposed Tuolumne supply. The city also owns lands in the Hetch Hetchy drainage area not in possession of the United States Government, and has the permission of the Government to use the Hetch Hetchy Reservoir site when needed, but with the understanding that the Lake Eleanor and Cherry Creek sources are to be developed first. It should be stated, however, that under the regime of Ex-Secretary of the Interior Ballinger, the city was instructed to show cause why the rights in the Hetch Hetchy Valley granted by the Government should not be revoked and that this order has yet to be brought to an issue.

*A paper read before the Engineering Section of the British Association for the Advancement of Science, England, Sept. 1, 1911.

How Much Time May a Teacher of Engineering Devote to Outside Professional Work?*

The position of the engineering teacher differs from that of most teachers, not only because an experience in engineering work is considered a desirable element in his preparation, but in that the practice of the profession in some form and amount in connection with his teaching is thought by many to be advantageous to professor, student and school.

The thought is that connection with professional engineering work gives valuable technical information, keeps the teacher in touch with his subject, vitalizes his work, interests the student, and advances the standing of professor and school.

Doubtless in many specialized subjects an arrangement may well be made by which a practicing engineer of standing may give part of his time to teaching a professional subject. Doubtless many a teacher has profited greatly through carrying on an engineering practice along with his teaching. Doubtless, too, public interests may be served through cooperation with engineering teachers. Evidently also teaching may be enlivened through references to actual engineering operations. But may not participation in engineering work be carried on in such a way as to detract from the results which may probably be expected from the teacher?

If a man, for any length of time, does full teaching work, and gives as much or more time and energy to outside professional work, which work suffers? If a prominent engineering teacher, head of a department in a great university to which students are drawn by virtue of his reputation and prestige, and who is advertised to give and direct instructional work, devotes three-fourths of his time and nine-tenths of his energy to engineering practice, is it to be expected that the students of this institution will profit much by his connection with it or that the department will show vigor and energy. When the participation in engineering work degenerates into mere necessity for filling out a meager salary, or even for extending the annual savings, without reference to the value of the work in the development or advancement of his usefulness as a teacher, the practice is indefensible.

Surely there is great chance for the abuse of opportunity. Surely there is need for caution. In the first place every educational institution should be put on such a basis that the instructor will not need to depend upon outside work to meet the year's necessary expenditures. Omitting the case of specialized instruction and of special provision for part time engagement, and agreeing to the advantage of keeping in touch with the professional activities in his specialty, may we not with prudence say that the limit of outside work should be placed below any amount which will interfere with efficient instruction, adequate attention to the needs of students, and the requisite energy and zeal and ambition for the teacher's work, and that in its nature the work should be limited to that which will extend the experience and training of the teacher, or make an addition to professional knowledge, or be of special service to the community or the public in some way not possible by the outside engineer.

And especial care should be taken that administrative duties and the direction or supervision of instruction be not interfered with by outside interests. Beyond these limits, participation in engineering activities may well be relegated to vacation periods and leaves of absence. When these limits are transgressed, it may be questioned whether the advantages of great names and high authorities compensate for loss of efficiency and vigor in instruction and of activity in the organization.

The Hatfield Dam, Hatfield, Wis., which was partly destroyed on Oct. 6 by flood in the Black River following the failure of the Dells Dam, six miles upstream, is to be rebuilt. The receiver of the La Crosse Water Power Co., owner of the dam, applied to the Federal court at Madison for authority to issue $150,000 receiver's certificates for rebuilding the dam. Judge Sanborn granted the desired authority. No information is at hand to show whether it is contemplated to restore the dam as it was before the flood, or to provide additional spillway capacity.

*From the Presidential Address of Prof. Arthur N. Talbot, Professor of Municipal and Sanitary Engineering, University of Illinois, before the Society for the Promotion of Engineering Education.

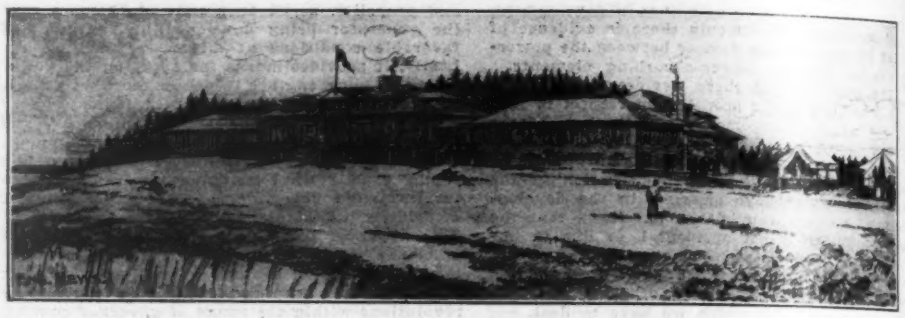
Notes From Engineering Schools.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—In Engineering News, June 1, 1911, was noted the proposed summer camp for civil engineering students at Gardner Lake, Me. Further details have now been furnished by the Institute. The land, at Crosby's Point, was given by an anonymous friend, and Mr. C. W. Eaton, of Haverhill, Mass., contributed $10,000 for the permanent buildings. These are shown in the accompanying figure, reproduced from the architect's drawings.

The central building is the administration house; to the left, as one faces the group, is the drafting-room, and to the right the dining-hall and kitchen. The last-named structure is T-shaped in plan, the whole front being for the dining-room and the tail accommodating the kitchen, storerooms, refrigerator and ice-house. Above are the chambers for the cooks, while in the basement is located the bakery, with a milk-room directly beneath the refrigerator. The administration building, or "Casino," has a living hall 30 ft. square, rising at the back past a railed balcony, with a great stone chimney to the roof. This will be made a comfortable meeting-room for students and instructors. Flanking the central hall are rooms for the instructing staff and physician. The upper story will have two class-rooms, 21 × 30 ft., and three sleeping-rooms opening to the front. The Casino will have a 90-ft. piazza along the front and will be finished in log-cabin effect.

The dining-room is to be connected with the administration building by a short covered piazza. The main hall has places for 168. The front of the building is 65 ft., and its depth, over all, 110 ft. It is set back from the front line of the main building about 20 ft. The drafting-room is 56 × 30 ft., with 24 tables, affording 72 working places. The room is high-studded, and fully half the wall space is window, affording an abundance of light. The whole group of buildings has an extent of more than 200 ft. along the front.

The students will find quarters in some 50 tents, ranged in a curve along the crest of the plateau, each on a wooden floor. A sanitary system for the camp is being designed by Mr. Leonard Metcalf; all quarters will be electric lighted. There will be flotilla of canoes and rowboats, with a few motorboats for hydrographic surveying. The camp courses will be obligatory to engineering students. Six or eight weeks here, following the second year at the Institute, will probably be the arrangement, and the subjects as now suggested will be civil, mining and sanitary engineering, advanced railway engineering of the third year and hydraulics of the fourth. The camp grounds, of more than six hundred acres, having a varied surface contour and a very wavy shore line, will in themselves furnish an excellent field for the surveying parties. The country outside is not in such a high state of cultivation that the work of the parties will injure it. There is at hand opportunity for railway and different kinds of hydraulic work, while the ocean, two or three miles distant, will give actual practice in determining sea level.



THE SUMMER CAMP OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY AT GARDEN LAKE, ME.

CORNELL UNIVERSITY.—Brazilian students of engineering here this year number 15. This unusually large number is ascribed to the present high price of Brazilian coffee, which has brought prosperity to the coffee growers of Brazil and enabled more parents to send their sons to American schools.

UNIVERSITY OF PITTSBURGH.—The Department of Industrial Research of the University, under the direction of Prof. Robert Kennedy Duncan, is undertaking a scientific study of the damage caused by soft coal smoke and fumes from metallurgical plants and factories in its various phases. This study will extend over a period of at least two years, and as much longer as is deemed necessary to accomplish the end in view. The research is undertaken under ideal conditions and with strong financial backing, so that results of great value are expected. Because of the vast importance of the subject and the wide field to be covered, Prof. Duncan is anxious to get in touch with people who are working along similar lines, and will be glad to receive letters from any one interested.

A Coal Mine Explosion at the Bardot mine, near St. Etienne, France, Oct. 19, is reported to have killed 26 men who were engaged in fighting a mine fire.

Spreading Rails are assigned as the cause of the derailment of the Cincinnati and Pittsburgh express on the Baltimore & Ohio R. R., near Cambridge, Ohio, Oct. 18. Five men were injured.

A Powder Explosion in a Mine near Harrisburg, Ill., Oct. 23, killed eight miners and injured eight others. The accident occurred as the shifts were changing and reports state that only 16 men were in the part of the mine affected when the accident occurred.

A Wooden Bridge Collapsed in Philadelphia, Oct. 23, killing two men and injuring seven others. The bridge was a viaduct for foot and wagon traffic across the Pennsylvania R. R. tracks at 65th St. and Woodland Ave. Reports state that at the time of the accident the bridge, which was weakened by age and decay, was being repaired.

Two Boiler Tubes Exploded, Oct. 22, on the U. S. Torpedo Boat "Tingey" when the vessel was about 15 miles off the Charleston, S. C., lightship. Two men were injured, one of whom died a few hours later. The "Tingey," at the time of the accident, was bound from Charleston Navy Yard for Hampton Roads. She was equipped with Thornycroft boilers.

An Aviator, E. B. Ely, was killed at Macon, Ga. on Oct. 19, while making a sensational "dip" at a state fair. It is supposed that he misjudged his elevation and started the dip at insufficient height. He was able to jump clear of his machine before striking the earth and so was not crushed by his engine, but his neck was broken by the fall. Ely's notable flights were between shore and ship, as previously noted in Engineering News.

The Canadian Lake Steamer "Emperor" was sunk, Oct. 17, at the lower entrance of the Canadian Lock at Sault Ste. Marie. An account of the accident given to the newspapers by the captain, who was not on board at the time, states that the first mate was in charge of the ship and that the boat left the lock at too high a speed, so that the mate became alarmed and ordered an anchor dropped. The water at this point was so shallow that in passing above the anchor the steamer's bottom was forced against it, punching a hole in her plates.

An Iron Mine Was Flooded Oct. 19 at Hibernia, N. J., after a blast which is believed to have made an opening through the wall of rock separating the flooded mine from an old disused shaft which had filled up with ground water. Reports state that the rock wall separating the two shafts was believed by the mine superintendent to be more than 200 ft. thick, so that no accident of the sort that occurred was anticipated. Twelve miners at work in the lower part of the mine, some 1,700 ft. below the surface, were drowned. The mine was the property of the Wharton Steel Co.

A Boiler Exploded in New York City Oct. 20 shortly before midnight at the plant of the Greenwich Cold Storage Co. on Greenwich St., between Beach and Hubert Sts. The boiler was of the horizontal return-tubular type and was set up in the basement directly beneath the sidewalk. Due to this location of the boiler outside of the building itself and to the peculiarly fortunate way in which the force of the explosion was expended, the damage was comparatively slight and was done chiefly in the basement. The sidewalk, about 12 ft. wide and built of stone slabs some six inches thick, was brought down for a length of about 100 ft. A fragment of a slab, about 4 × 3 ft., from directly above the boiler room was thrown across the street, and several smaller pieces were thrown against the Ninth Ave. elevated railway structure immediately overhead. One of the many fortunate circumstances of the accident was that no serious injury was done to the elevated structure, although there were three of the supporting columns along the curb line with their foundations projecting into the basement beneath the sidewalk that was wrecked. One of these columns, in fact, had its foundation directly in the boiler room and so close to the firing door of the exploded boiler that the fireman was accustomed to leave his slice bars standing in the convenient angle formed between the foundation pier and the basement wall. On the other side of the boiler were the foundation piers for the front wall of the building, and they too escaped without serious injury.

The boiler was set with its length parallel to the curb line and with its rear end close to the brick wall which served as a partition between the sub-sidewalk cellar of the Greenwich Cold Storage Co. and that of the next building to the north. It faced another similar boiler set directly south of it, with a space of perhaps eight or ten feet between the two for the firing floor. This second boiler was not much damaged except for the smashing of its cast-iron front. The force of the explosion drove the north boiler rear-end-first through the partition wall, which was about 2 ft. thick, and on through the cellar below the sidewalk to the corner of Hubert St., some 70 or 80 ft. from its original position. Apparently it brought down the sidewalk slabs as it passed by scraping away their supports. A few slabs lay upon the boiler in its final position. This was at Hubert St. where it encountered the solid basement wall backed-up by earth at the Hubert St. curb line. After the accident, the boiler lay with its rear end slightly crumpled against this wall and its other end resting on the basement floor. The rear end had apparently hit near the top of the wall and, in fact, it must have risen partly through the sidewalk, so that only the lower half of the rear tube sheet encountered the wall. The momentum of the tubes from the upper half of the sheet caused them to keep on going north, drawing themselves neatly out through their holes in the tube sheet for half their length. In fact, some of the tubes escaped entirely and continued on across Hubert St., wrecking the corner saloon.

The steam nozzle was broken or sheared off at the start, remaining, with the lever safety valve, attached to the steam main. Only the lower flange, or collar, of the nozzle was left on the boiler shell. The cover of the manhole on the top of the boiler was also missing. It was probably scraped off when the boiler went through the brick partition. The shell itself was apparently very little damaged and without a rip. The tubes were in good condition except for the crushing and bending of a few of them against the wall when the boiler came to rest. The only clue to the nature of the explosion was the condition of the tube sheets. Both of these were dished or bulged outwardly. It appears probable that an excessively high pressure was occasioned in the boiler in some way and bulged out the tube sheets. This would pull the tubes loose at one end or the other, and it appears that they were pulled out of the forward sheet, so that the steam escaped from the tube-sheet holes at this end and the reaction propelled the boiler in the opposite direction.

The boiler was used to supply steam for a large vertical ammonia compressor, which was set up in the basement in a space adjoining the boiler room with its cylinders rising through the floor into the engine room above. Pipes to the ammonia tank were fractured by the explosion and the escaping gas filled the basement and lower floors of the building, giving rise to a report that the explosion was that of an ammonia tank.

The engineer in charge at the time of the accident was new to the job, according to the newspaper reports. One account has it that he had just been engaged on the afternoon following which the accident occurred. When the boiler exploded, he was in the boiler room, together with a negro helper, but neither of these two men was even badly injured. Six or eight persons, however, were more or less severely injured by the flying boiler tubes and debris. The property damage is estimated at about $30,000, including damage done in the cold storage company's basement by water from the high-pressure fire main. The basement was flooded by the breaking off of a fire hydrant installed in front of the building near the curb. The hydrant was supplied by a pipe passing through the sidewalk and then, with a 90° bend, through the front basement wall into the street. The pipe was broken off at this bend and it appeared that the hydrant had been dragged down by the sidewalk when it fell into the basement.

Plans for a 190-ft. Dam at Baltimore, Md., are well advanced and bids for construction will soon be advertised. The dam will form a 3,000,000,000-gal. water-works storage reservoir on the Gunpowder River, and will be of a cross-section making possible a future increase in height to 270 ft., instead of to the 237 ft. recommended by Messrs. F. P. Stearns and J. R. Freeman, Ms. Am. Soc. C E., some time ago. A few further particulars were noted on p. 189 of our issue of Aug. 10, 1911. Mr. Ezra B. Whitman, M. Am. Soc. C. E., is now Water Engineer of Baltimore.

The Relation of Sewage Disposal at Cleveland, Ohio, to both the water-supply of the city and to the quality of the lake water at bathing beaches near the main sewer outlet, is to be investigated and reported upon by Mr. R. Winthrop Pratt, M. Am. Soc. C. E., who has recently resigned as Chief Engineer of the Ohio State Board of Health in order to take up this work. Recommendations for obtaining a pure water-supply for the city and at the beaches will be made. Mr. Robert Hoffman, M. Am. Soc. C. E., is Chief Engineer of the Department of Public Service of Cleveland.

Personals.

Mr. B. H. Bendheim, formerly the San Francisco, Cal., representative of the F. E. Newberry Electric Co., of Illinois, has been made Vice-President and Manager of the same company, with headquarters in Chicago, Ill.

Mr. W. H. Dittoe, Jun. Am. Soc. C. E., formerly Assistant Engineer of the Ohio State Board of Health, has been appointed Acting Chief Engineer of the same, succeeding Mr. R. Winthrop Pratt, M. Am. Soc. C. E., resigned.

Prof. F. P. McKibben, M. Am. Soc. C. E., head of the Department of Civil Engineering, Lehigh University, has been appointed Consulting Engineer by the Pennsylvania State Water Supply Commission which is investigating the causes of the Austin flood disastser.

Mr. C. Gordon Reel, Assoc. M. Am. Soc. C. E., formerly a consulting engineer of Kingston, N. Y., and recently Deputy Superintendent, New York State Highway Department, has been appointed Superintendent, succeeding the late William H. Catlin.

Mr. Walter McCulloh, M. Am. Soc. C. E., for the past four years Consulting Engineer to the New York State Water Supply Commission and its successor, the Conservation Commission, has resigned and has resumed his private practice at Niagara Falls, N. Y.

Mr. E. R. Buckley, M. Am. Inst. M. E., for a number of years Director of the Missouri Bureau of Geology and Mines, and mining specialist, of Rolla, Mo., has opened an office at 1364 Peoples Gas Bldg., Chicago, Ill., for practice as a consulting mining geologist and engineer.

Mr. George Y. Skinner is associated with Samuel Parsons & Co., Landscape Architects, of New York City, as Civil and Consulting Engineer. In our columns of last week Mr. Skinner was said to have taken a position with this firm, which tended to convey a wrong impression of his position.

Mr. L. G. Krause has resigned as Assistant Engineer of the Delaware, Lackawanna & Western R. R., at Syracuse, N. Y., and will enter private practice as a member of the firm of Clark & Thompson, Engineers and Real Estate Brokers, Pleasantville, N. J. Mr. Clark has retired from the business.

Mr. B. C. Donham, M. Am. Soc. C. E., formerly with J. G. White & Co., Inc., of New York City, has opened offices at 52 Broadway, New York City, under the firm name of B. C. Donham & Co., to engage in management, engineering and construction work. Mr. Donham is a graduate of the Massachusetts Institute of Technology, class of 1895.

Prof. O. M. Leland, M. Am. Soc. C. E., of Cornell University, and Mr. John F. Hayford, M. Am. Soc. C. E., Dean of the College of Engineering of Northwestern University, have been appointed two members of a commission to be composed of four engineers who will settle the boundary dispute between Costa Rica and Panama. The other two commissioners will be representatives of the two countries.

Dr. N. C. Ricker, Fellow of the American Institute of Architects, and Professor of Architecture at the University of Illinois, and Prof. I. O. Baker, M. Am. Soc. C. E., in charge of the Department of Civil Engineering, University of Illinois, have been appointed by Governor Deneen members of the Commission to Revise and Codify the Building Laws of the State of Illinois. Dr. Ricker is Chairman of the Commission.

Messrs. M. D. Burke, M. Am. Soc. C. E., and Wm. M. Venable, M. Am. Soc. C. E., announce the dissolution of the partnership of Burke & Venable, Consulting Engineers, of Cincinnati, Ohio, to enable Mr. Venable to devote all his time to the interests of the Blaw Collapsible Steel Centering Co., of Pittsburgh, Pa., where Mr. Venable will hereafter make his headquarters. Mr. Burke will continue in business at the present office of the firm in Cincinnati.

Mr. T. S. Tullen, of Topeka, Kan., has been awarded the Ryerson Scholarship at Purdue University. The Ryerson Scholarship was founded in 1903 by the Joseph T. Ryerson Co., of Chicago, Ill., and is awarded by a committee of the American Railway Master Mechanics Association to a candidate who has had at least one year's experience in the motive power or car department of some railway. The appointee has been a draftsman and machinist apprentice with the Atchison, Topeka & Santa Fe Ry. for the past three years.

Mr. Harwood Frost, M. Am. Soc. M. E., and Mr. George W. Clark, of Chicago, Ill., have acquired the controlling interest in the Brown Portable Elevator Co., of Portland, Ore., formerly owned by Messrs. Frank H. and Fred H. Brown. Mr. Frost, who was formerly Manager of the Engineering News Book Department, has been elected President, and Mr. Clark, formerly the Chicago representative of the firm, has been chosen Vice-President. Mr. Fred H. Brown remains on the board of directors and will become Manager of the Western branch at Portland, Ore. Mr. George H. Frost, founder and until recently proprietor of Engineering News, is a member of the board of directors.

Prof. Charles M. Spofford, M. Am. Soc. C. E., Hayward Professor of Civil Engineering at the Massachusetts Institute of Technology, has been appointed the head of the department of civil and sanitary engineering at this institution. Since the resignation of Prof. Swain, three years ago, to accept a similar position at Harvard University, the responsibilities of dean have been divided among the three professors in civil engineering. The present change comes from the request of Prof. C. Frank Allen, the senior in the department, to be relieved of his portion of the executive duties. Prof. Spofford is a graduate of the Massachusetts Institute of Technology, class of 1893, and was an instructor and assistant professor there until called to take the chair of civil engineering at the Brooklyn Polytechnic Institute in 1905. Three years ago he returned to Boston to become Professor of Civil Engineering at his alma mater.

Mr. R. Winthrop Pratt, M. Am. Soc. C. E., has resigned as Chief Engineer of the Ohio State Board of Health to accept the position of Special Engineer for the city of Cleveland, Ohio, to determine by such studies, experiments, and tests as

may be necessary, the relation which the disposal of the sewage bears to its water supply, and also to the quality of the lake water at the various bathing beaches near the main sewer outlet. A report will be made recommending the most suitable and practical means of obtaining pure water for the city and at the beaches. Mr. Pratt graduated from the Massachusetts Institute of Technology in 1898. From 1899 to 1903 he was Engineering Assistant and Assistant Engineer with the Massachusetts State Board of Health. Since 1903 he has been Chief Engineer of the Ohio State Board of Health, with the exception of one year, 1909-1910, on leave of absence, during which he was Director of Sanitary Engineering of the Republic of Cuba. In connection with his new position he will be associated with Mr. Robert Hoffman, M. Am. Soc. C. E., Chief Engineer, Department of Public Service of Cleveland.

Obituary.

S. R. Poulin, M. Can. Soc. C. E., District Engineer of the Transcontinental Ry. of Canada, at St. Boniface, Man., died at Winnipeg, Man., on Oct. 14.

Malcolm M. McDonald, a mining engineer and promoter, of Butte, Mont., died in New York City on Oct. 23. He was extensively interested in gold mines in Montana and Nevada.

Samuel Hooper, Provincial Architect for the Province of Manitoba, Canada, died in London, England, on Oct. 20, from asthma. He was one of the most prominent architects of Winnipeg, where during the last 30 years he designed many important buildings. For the past 10 years he had charge of the design of all public buildings in that city.

Dr. Agrippa Nelson Bell, of Brooklyn, N. Y., died on Oct. 15 at his home in that city. He was 91 years old, a veteran of the Mexican and Civil Wars, and a prominent physician for many years. From 1873 to 1904 he was proprietor and editor of the "Sanitarian," a publication devoted to medicine and public health and a pioneer in its field, being for many years the only paper devoted to sanitary and public health subjects. He was also an author of books and papers on medicine and hygiene. He is survived by three daughters and one son, Dr. Harry K. Bell, of New York City.

Robert Mather, Chairman of the Board of Directors of the Westinghouse Electric & Manufacturing Co., of Pittsburgh, Pa., died at his home in New York City on Oct. 24. He was born in Salt Lake City, Utah, on July 1, 1859. He began work at an early age, but by great industry prepared himself for Knox College, where he graduated in 1882, and obtained a Master's degree in 1885. In the meantime he was employed in the office of the treasurer of the Chicago, Burlington & Quincy R. R., where he spent his spare time studying law. He was admitted to the Illinois bar in 1886, and in 1889 was appointed local attorney of the Chicago, Rock Island & Pacific Ry. From this position he rose to that of General Counsel of the same railway, and in 1904 he was chosen President of the Rock Island Co. In January, 1909, at the time of the reorganization of the Westinghouse Electric & Manufacturing Co., he was elected Chairman of the Board of Directors. Since then he had given the greater part of his time to this work. He was a director of numerous other large corporations.

Walter Herbert Sears, M. Am. Soc. C. E., for about five years Chief Engineer of the Aqueduct Commissioners, in charge of the extensions of the Croton water supply of the City of New York, died Oct. 7, 1911, at his home in Plymouth, Mass. Mr. Sears was born in Plymouth in 1847, and graduated from the Massachusetts Institute of Technology in 1868. The following year was spent on Prospect Park, Brooklyn, and the second year in the office of Mr. John B. Henck, Civil Engineer, in Boston. From 1872 to 1874 Mr. Sears was Chief Engineer for the construction of the water-works of Winchester, Mass.; from 1875 to 1879 he held a similar position in charge of preliminary surveys and construction of water-works for Pawtucket, R. I. The following year he constructed water-works for Stillwater, Minn., and afterward an extension of the water-works system of Winchester, Mass. In 1883-1884 he was an assistant engineer of the American Bell Telephone Co., placing wires underground in the vicinity of Boston and Washington. As Resident Engineer he constructed a new water supply for Beverly, Mass., and two years were spent as Chief Assistant Engineer of the East Jersey Water Co., at Paterson, N. J. In 1891 he was Chief Assistant Engineer on the additional water supply, of Rochester, N. Y. For the succeeding 10 years Mr. Sears was engaged in general engineering practice, including the renewal of the water supply system of Plymouth and Lincoln, Mass., and plans for a new water supply for Grand Rapids, Mich. In 1903 he became a Department Engineer under the Commission on Additional Water Supply, appointed by Mayor Low to investigate the Catskill and other water projects for New York City, Mr. Sears having charge of the Catskill department. Following this engagement Mr. Sears was Resident Engineer for the Northern New Jersey Flood Commission, with offices at Paterson, N. J. In 1904 he became Division Engineer of the Croton River Division for the Aqueduct Commissioners, and had charge of work in the vicinity of Katonah, N. Y. From Aug. 1, 1905, to Jan. 9, 1906, he was Acting Chief Engineer, and from the latter date to April 1, 1910, Chief Engineer of the Aqueduct Commissioners. During this period the Cross River reservoir was completed and the Croton Falls reservoir construction begun and carried nearly to completion. During the latter part of his engagement Mr. Sears was taken ill and was unable to return to active work. (Obituary note prepared by Mr. Alfred D. Flinn, M. Am. Soc. C. E., Department Engineer, Board of Water Supply, New York City.)

Engineering Societies.

COMING MEETINGS.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Nov. 2-4. Annual meeting at Cincinnati, Ohio. Secy., Edward H. Reisner, 20 West 44th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 13-16. Annual meeting at Richmond, Va. Secy., Clinton R. Woodruff, 705 North American Bldg., Philadelphia, Pa.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Nov. 14-17. Annual convention at Rochester, N. Y. Secy., E. L. Powers, 150 Nassau St., New York City.

AMERICAN RAILWAY ASSOCIATION.
Nov. 15. Semi-annual meeting at Chicago, Ill. Secy., W. F. Allen, 75 Church St., New York City.

NATIONAL FOUNDERS' ASSOCIATION.
Nov. 15-16. Annual convention at New York City. Secy., F. W. Hutchings, 915 Hammond Bldg., Detroit, Mich.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 16-17. Annual meeting at New York City. Acting Secy., D. H. Cox, 29 West 39th St., New York City.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
Nov. 17-18. Annual meeting at Canton, Ohio. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

NEW JERSEY SANITARY ASSOCIATION.
Nov. 24-25. Annual meeting at Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 4. Annual meeting at New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Dec. 4-9. Annual meeting at Havana, Cuba. Secy., Wm. C. Woodward, Washington, D. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 5-8. Annual convention at New York City. Secy., Calvin W. Rice, 29 West 39th St., New York City.

NATIONAL IRRIGATION CONGRESS.
Dec. 5-9. Annual session at Chicago, Ill. Secy., Arthur Hooker, 214 Hotel La Salle, Chicago, Ill.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 11-13. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 12-14. Annual convention at Washington, D. C. Secy., Glenn Brown, the Octagon Washington, D C.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 20-22. Annual meeting at Washington, D. C. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 27-29. Annual meeting at St. Paul, Minn. Secy., J. B. Davidson, Ames, Iowa.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27-Jan. 3. Annual meeting at Washington, D. C. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

Engineers' Club of St. Louis.

A party of members made a trip from St. Louis to Keokuk, Iowa, Oct. 14, to inspect construction work on the Keokuk power development project.

American Institute of Electrical Engineers.

At a meeting of the Board of Directors on Oct. 13, it was decided that a regular meeting of the Institute shall be held at Portland, Ore., in April, 1912.

Municipal Engineers of the City of New York.

A paper entitled "The Contractor's View of City Contracts and Specifications" was presented by Mr. C. A. Crane at the regular meeting held in the Engineering Societies' Building, Oct. 25.

American Society of Civil Engineers.

At the regular meeting of the San Francisco association of members of this society on Oct. 20, Mr. H. T. Cory presented a paper entitled "The Irrigation Developments on the Lower Colorado River with Their Allied Problems."

Association of Railway Electrical Engineers.

The fourth annual convention will be held at Chicago, Ill., Nov. 6-10. The program of papers to be presented includes the following: "Car Ventilation," "Shop Practice," "The Gas-Electric Car," "Train Lighting Practice" and "Industrial Trucks for Railway Service." The secretary is Mr. Jos. A. Andreucetti, C. & N. W. Ry., Chicago, Ill.

American Society of Civil Engineers.

At the regular meeting of Oct. 18, in New York City, Mr. George Gibbs presented his paper on "The New York Tunnel Extension of the Pennsylvania Railroad; Station Construction, Road Track, Yard Equipment, Electric Traction and Locomotives." An abstract of this paper was published in Engineering News in the issues of Oct. 5 and 12, 1911.

American Economic Association.

The annual meeting will be held at Washington, D. C., Dec. 27-30, at the same time as the meeting of the American Association for the Advancement of Science. The Secretary is Mr. T. N. Carver, Harvard University, Cambridge, Mass. The American Statistical Association, the American Sociological Society and the American Association for Labor Legislation will meet in Washington during the same week.

Cleveland Engineering Society.

At the regular meeting on Oct. 24 Mr. Charles S. Gingrich, of the Cincinnati Milling Machine Co., presented a paper on "Modern Machine Shop Milling Processes." Mr. Gingrich described continuous milling by two processes, the rotary process and the reciprocating process, and gang milling. He emphasized the importance of using proper cutters and discussed a new development in the design of milling cutters.

The Engineers' Society of Pennsylvania.

At a meeting held Oct. 16, at Harrisburg, Pa., Mr. A. Carson Stamm, of Harrisburg, gave an address entitled "The Sherman Anti-Trust Law and Its Interpretation by the United States Supreme Court."

The Lecture Committee announces that at an early date Prof. Frank P. McKibben, of Lehigh University, will talk on "The Austin Dam Failure and the Resulting Catastrophe."

American Association for Highway Improvements.

Among those who will present papers at the road congress to be held by this association in Richmond, Va., Nov. 20-23, are the following: W. A. McLean, Provincial Engineer of Ontario, Canada; W. W. Crosby, State Highway Engineer of Maryland; A. N. Johnson, State Highway Engineer of Illinois; A. H. Blanchard, Professor of Highway Engineering, Columbia University, and P. St. J. Wilson, State Highway Commissioner of Virginia. The papers by these men will be presented on the second day of the congress, which will be known as "highway engineers' and contractors' day."

American Railway Bridge & Building Association.

At the 21st annual convention at St. Louis, Mo., Oct. 17-19, the committee reports presented included the following: "Best Method of Numbering Bridges," "Buildings and Platforms for Small Towns," "Sash, Size and Kind of Glass That Is Economical for Roundhouses and Shop Buildings," "Plans of Fireproof Oilhouses," "Best Method of Fireproofing Frame and Trestle Bridges," "Derricks or Other Appliances for Handling Heavy Material in Supply Yards," "Pumping Engines, Best Kind and Most Economical to Use—Gasoline, Oil or Electric," "Records of Bridges, Buildings and Other Structures, Showing Cost of Construction and Maintenance," "Concrete Tank Construction and Recent Developments and Suggestions," "Feasibility of Using Brick Veneer for Station Buildings," "Roofs and Roof Coverings."

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